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The Unexpected

Contributed by C. H. WILLEY.

IT IS the unexpected that always happens, and how often we could avoid disaster or humiliation if we kept our eyes open. A young engineer of my acquaintance recently came to see me and pour out his troubles in the hope that I could aid him.

HE WAS in charge of a factory power plant and had gotten along pretty well for several years, keeping things running. He felt quite content with his job and really sort of prided himself that things went so smoothly. And now he had received a bump that startled him, and he professed he was up against it and worried. The factory owners had called him into the office and told him that they wished him to go over the power plant with a fine-tooth comb and submit a report on items that were causing waste of steam or that, in his opinion, were so antiquated and inefficient that they could be dispensed with. They also wished him to make recommendations as to new and modern devices that would return a reasonable interest on the investment.

THEY explained that as fuel prices were now so high and the prospects were that they would remain so for an indefinite length of time, they desired to bring the old plant up to a more modern standard. This rather large order caught the young engineer wholly unprepared. When asking me to assist him, he said: "Gee! I never expected the old crabs would ever spend any money on improvements. Why, every time I sent in a requisition for supplies, they grumbled over it and cut it down, and now here they are asking me to remodel the plant!"

SEEING that he was up against it, I tried to help him out and succeeded. I wonder how many more of his kind are working blindly along each day. These are days of quick decisions on the part of power-plant and factory owners. Many who have been skimping along on old dilapidated equipment all at once decide to yank out the old junk and adopt the modern.

THE new is always trying to crowd out the old everywhere, and to those engineers who would keep up with the times I would give this advice: Keep your eyes peeled for new ideas and be alert to grasp them. Get acquainted with every up-to-date device that could be applied to your plant to aid efficiency and economy. Do not allow the small details of everyday work to crowd out new thoughts and modern ideas. Become a spare-time student of your trade paper—it will keep you abreast of the times.

Wreck of a Thirty-five Thousand Kilowatt Turbine

An account of the wreck of a 35,000-kw. horizontal single-cylinder impulse steam turbine in the O Street Station of the Boston Elevated Railway Co., Boston, Mass., Feb. 14, 1918

A 35,000-kw. 20-stage 1500-r.p.m. 25-cycle horizontal single-cylinder impulse steam turbine in the O Street Station of the Boston Elevated Railway Co. was completely disabled and seriously damaged while in service Thursday, Feb. 14, 1918. There were no casualties and no one was injured. A distorted cast-iron diaphragm in the 18th stage presumably fouled the 18th wheel, breaking off the buckets, after which the buckets and diaphragms from the 18th stage on to the last, or 20th, wheel, also the entire casing, were destroyed. There are excellent photographs of the wreck in existence but are not available for publication without the consent of the manufacturers of the turbine, which consent is refused. A turbine of a type similar to that which was wrecked is, however, shown in Figs. 1 and 2.

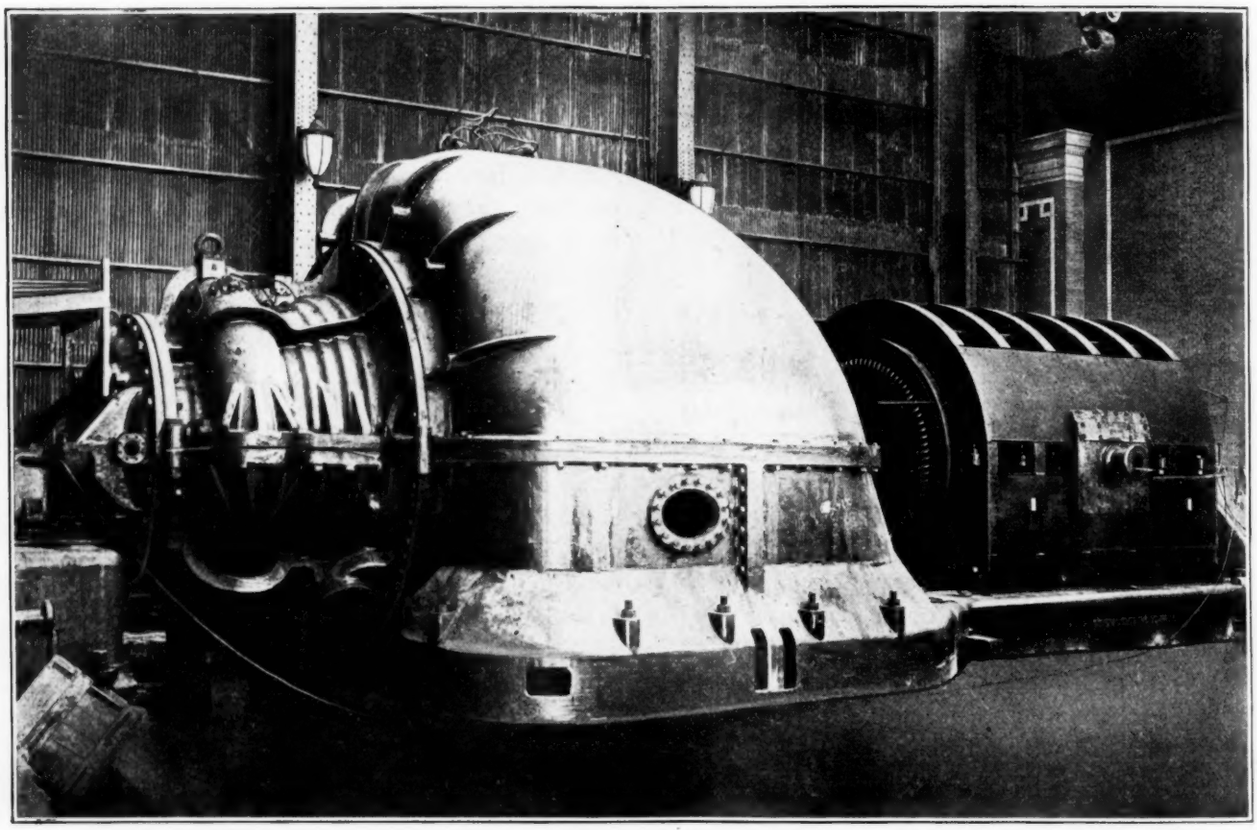


FIG. 1. CASING OF TURBINE OF TYPE SIMILAR TO THAT DAMAGED IN BOSTON

To get a proper perspective of this accident one should go back a year ago, when the turbine was installed. At this time trouble of a nature similar to that which wrecked the turbine was experienced; the date was Feb. 14, 1917. At that time the 18th diaphragm became distorted; that is, it deflected at its edge in the direction of the 18th wheel, rubbed the buckets where they join the wheel and stripped the buckets from the 18th and 19th wheels, seriously damaging the 18th and 19th diaphragms. This happened when the machine was being given trial runs. Rubbing began and the throttle was tripped, after which the damage to the buckets and diaphragms followed. When the buckets let go, the speed was below the normal 1500; perhaps 1000 or 1200 r.p.m.—no one knows.

After the accident of Feb. 14, 1917, the capacity was reduced to 20,000 kw. from Mar. 17 to May 23, while repair parts were being made, by locking closed the secondary valve, which admits steam to the 7th stage. The repair parts in place and the machine in service, annoyance was given because the machine would not carry the load with its swings of 2500 kw. above the rated 35,000 kw. under the operating conditions. When these swings came, the cycles dropped from the normal 25 to 24. The purchaser was most anxious that the turbine carry the swings, and it was suggested that nineteen 1½-in. holes to be drilled in the eighth diaphragm in front of the eighth wheel. See Figs. 3 and 4. The holes were drilled to allow high pressure steam to that stage. The turbine then carried these swings.

The machine was designed for 200 lb. gage pressure

at the turbine throttle, 200 deg. F. superheat and 29 in. vacuum at 30 in. barometer. There was a pressure drop of 4 lb. in the steam line between the boilers and the throttle, or from 200 lb. to 196 lb.; the drop through the governor valves was also slightly more than normal. The builder states that on Aug. 15 last, with 188.7 lb. gage pressure at the throttle, 132 deg. F. superheat and 28.7 in. vacuum, the turbine carried 36,500 kw., and that based on these figures the capacity would be 39,000 kw. under contract conditions.

Rumor has had it that thrust-bearing trouble was responsible for the accident of Feb. 14, 1918. In view of this it is well to point out that the most authoritative statement claims that what little thrust-bearing trouble did arise did not present itself until December, 1917. The trouble was not inherent in the bearing, but was due to oil of poor quality, it having been used for too long a time, as seems evident from the gradual rise in temperature of the oil and from the chocolate-colored deposit left on the bearing. After this incident new oil was put in and the bearing burned out a week later, caused likely by interference with the oil circulation. Slight changes were made to the circulating system, and the machine was put in service on Jan. 26, 1918, after which no further trouble was experienced with the bearing. So, evidently the bearing had no influence whatever on the present accident.

With the foregoing in mind, take up the details of the accident. On Feb. 14, 1918, at 4:55 p.m., when the evening peak load was mounting, the machine was heard to rub and observed to vibrate. Members of the operating crew climbed on top of the platform to adjust the thrust bearing, hoping to stop the rubbing and consequent vibration. The statements of these men say that the first vibration was heavy, that it was of the nature of a shock, after which there came a second with such evident commotion within the casing as to cause all hands to seek safety by running to cover.

At 5:01 p.m., six minutes after the first sign of serious rubbing, the damage was completed and pieces of metal had ceased to fly about the room. [This time is variously given as 3, 4, 5 and 6 minutes; but 6 minutes is the most authoritative as it is that given by the men who were handling the machine and the switchboard.] The period during which pieces of the turbine were flying about and while the low-pressure end of the rotor and the casing were going to pieces was likely not more than 30 seconds.

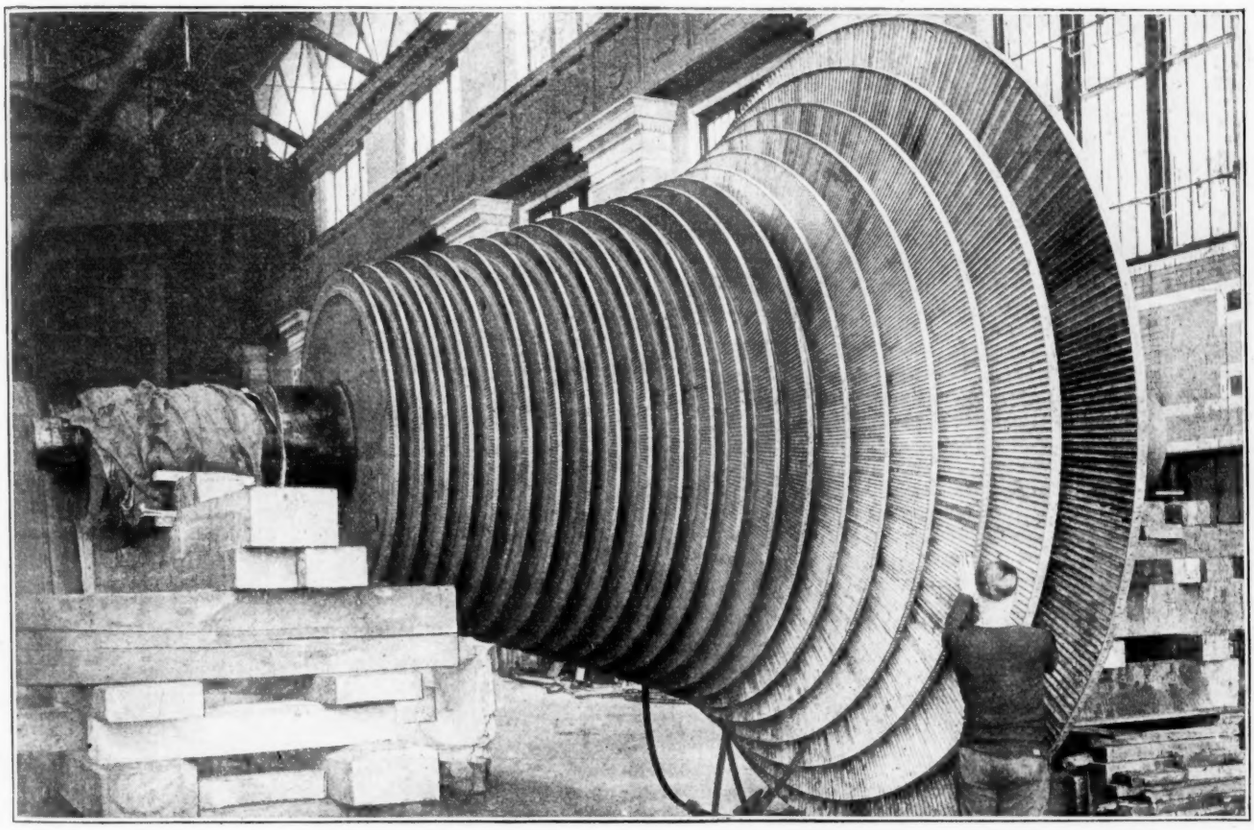


FIG. 2. ROTOR OF THE TURBINE THE CASING OF WHICH IS SHOWN IN FIG. 1

Now to go back to the time that the first severe rubbing was heard. At this time the Central Station of the same company, which, of course is tied in with the O Street Station, dropped its load of about 10,000 kw. owing to a station blowout. Prior to this the machine now damaged was carrying 32,000 kw. This turbine was practically the only unit to take the system's load—there having been some trouble at the Lincoln Wharf Station—and tried to take all the load dropped when the blowout occurred, by opening wide its secondary valve. The quick opening of this valve so suddenly increased the steam pressure in the low-pressure stages that the impact was probably sufficient either to initially and seriously distort the 18th dia-

phragm or to further distort it if already deflected, sufficiently to make it further foul the 18th wheel.

When the secondary valve opened, the machine was said to take on 37,000 kw. Whether it took but 37,000 or, because of the momentum of the rotor, took every kilowatt of that 10,000, no one knows for it seems there was no instrument to record the load it did take. But it appears certain that the machine took a very heavy load and took it with the suddenness of a hammer blow. The cycles had dropped from the normal 25 to 24 when the switchboard operator noticed that the turbine was carrying 37,000 kw. Unable to stop the rubbing, the operator on the floor signaled the switchboard man to take off some load, which he did, dropping it to into the condenser, crushing the tubes for a depth of about two feet. When this frame broke, it is probable that the 19th and 20th diaphragms let down on the shaft, or more correctly on the wheelbases, and either revolved with the shaft, then broke due to centrifugal force, or they were broken at the time their supporting frame cracked by reason of being struck by fragments from other stages. These diaphragms, like all others in the low-pressure end of this and other large turbines, were of cast iron. The centrifugal force may have broken them, but at any rate they were broken in many pieces, and these were hurled against the outside casing with force enough to blow out the whole end of this casing and break the great web or bracket,

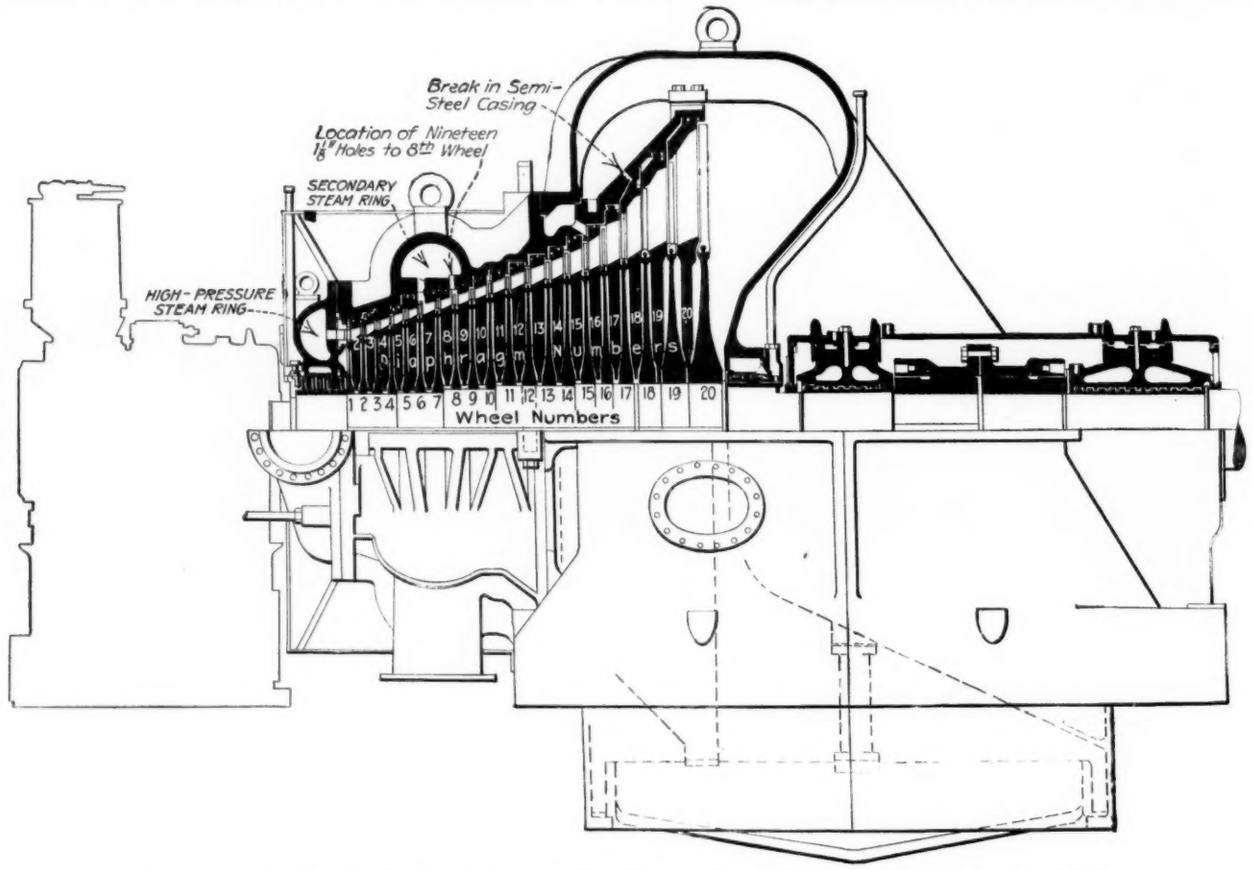

Break in Semi-Steel Casing
Location of Nineteen 1⅛" Holes to 8th Wheel
SECONDARY STEAM RING
HIGH-PRESSURE STEAM RING
Diaphragm Numbers
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Wheel Numbers

FIG. 3. LONGITUDINAL SECTION OF 35,000-KW. TURBINE DAMAGED IN BOSTON ACCIDENT

32,000 kw. It was soon after this that the turbine went to pieces. The buckets on the 18th wheel ripped off, they fouled the 19th diaphragm, which in turn fouled the 19th wheel and the 20th diaphragm.

It is interesting to note that the buckets from the 18th wheel are broken identically as were the buckets from this wheel in the accident of a year ago. In the recent accident the same evidence of heating of the buckets where they join the wheel is apparent as was apparent on the buckets damaged a year ago. Fig. 5 shows where the buckets were rubbed and how they left the wheel. These buckets are indeed tough, as shown in Fig. 7. The 20th, or last, wheel has all or nearly all its buckets, though they are severely bent and twisted.

Reference to Figs. 3 and 6 shows that a break occurred in the semi-steel frame which holds the diaphragms in the low-pressure end. This conical frame dropped that supports the bearings on the generator side of the turbine. The significant fact is that these diaphragms are the only large pieces of metal to completely break up and leave the turbine. It was some of these pieces that went through the roof and terra cotta temporary end wall of the building. The direction taken by the principal fragments that left the turbine was radially of the shaft, though five pieces went through the building wall near the generator end of the shaft. A piece weighing 70 lb. went through one of the switchboard gallery windows, coming to rest at the other side of the gallery room. One large chunk of diaphragm fell about a quarter of a mile from the scene of the accident. A man was punching the time clock in the turbine room, the clock being at an angle of about 45 deg. from the turbine, when the crash came. As he punched the clock, a piece of metal tore through the board holding the time cards.

There are some interesting speculations as to what broke the conical semi-steel casing which held the low-pressure diaphragms and which inclosed the last five wheels. The man qualified to speak most authoritatively, that is, the eminent designer of the turbine, shows by calculations that high-pressure steam at that point, caused by possible closure of the buckets in the 19th diaphragm, could not do it, as the pressure on the ledges *A*, *B* and *C*, Fig. 6, probably was not more than 186 lb. at most. He thinks that the expansion of the 18th diaphragm, caused by the diaphragm rubbing the buckets on the 18th wheel, may have forced the ring *D*, which is the outside or ring of the 18th diaphragm, to exert pressure enough on the casing to fracture the latter. Others think that it was broken by pieces of diaphragm being jammed against it. A combination of these causes seems not improbable.

The whole turbine casing is ruined, being severely cracked at the low-pressure end, with other smaller cracks extending to the high-pressure end. As stated, the great bracket, or web, supporting the bearings between the turbine and generator dropped away, letting the bearings free. The low-pressure labyrinth packing was destroyed. There was thrust enough to break the collars at the bearings and to push the exciter, mounted on the end of the mainshaft, forward sufficiently to break the four spider brackets supporting the extreme end of the exciter shaft. The collars on the thrust bearing at the high-pressure end are intact.

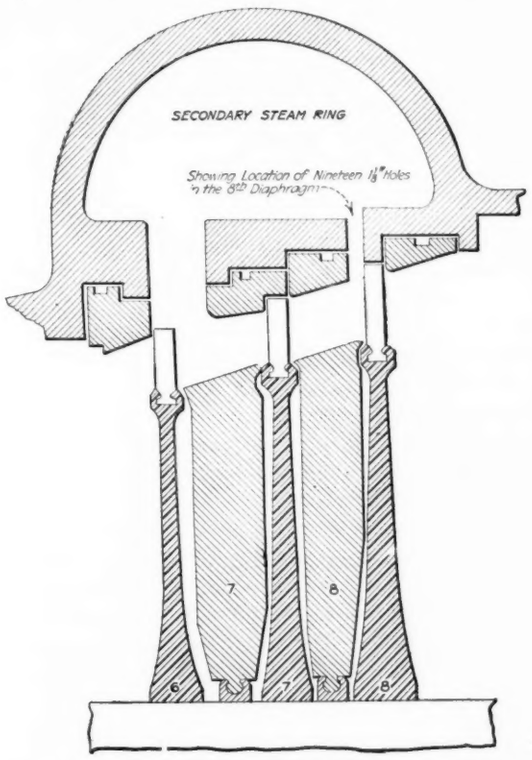


FIG. 4. LOCATION OF HOLES IN EIGHTH DIAPHRAGM

All wheels and diaphragms up to and including the 17th stage are intact. The 18th, 19th and 20th wheels are intact, though their blading is either gone or ruined. There is one small piece out of the rim of the 20th wheel, broken out, presumably, by being struck a tremendous blow by a fragment of diaphragm.

Fortunately, the automatic throttle valve which controls steam to the turbine tripped, either from vibration or because one of the operating crew tripped it by hand. The men do not remember tripping the valve, and one of those present who most likely would trip it is not sure whether he did or did not. It was most fortunate that this did trip, for if it had not one can

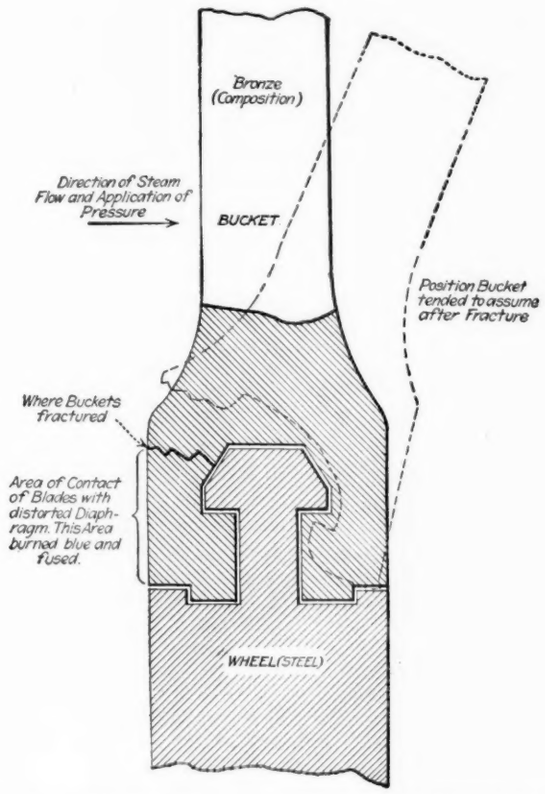

Bronze (Composition)
Direction of Steam Flow and Application of Pressure
BUCKET
Position Bucket tended to assume after Fracture
Where Buckets fractured
Area of Contact of Blades with distorted Diaphragm. This Area burned blue and fused.
WHEEL (STEEL)

FIG. 5. HOW BUCKETS ON THE EIGHTH WHEEL WERE BROKEN

but conjecture where the damage and loss of life may have ended. Vibration probably tripped the valve, as valves of this design are held open by a catch resting on a knife-edge steel.

That the turbine wheels, especially the 20th, are intact is most gratifying. Nothing could more thoroughly prove the correctness of the designer's calculations and more completely convince one of the adequacy of the factor of safety of these wheels.

There were some who were apprehensive about this 20th wheel. In fact, the Massachusetts Institute of Technology was engaged to check up the stresses in the wheel, determine the factor of safety, etc. The results of these checking tests showed astonishingly close agreement with the designer's values. The factor of safety was a little more than four.

On going over the matter with characteristic thoroughness, the professors at "Tech" were in no way apprehensive about the wheel going to pieces. They did express an opinion that because of the shape of the wheel (thick at the hub, then growing thin as the rim is approached) fracture might develop if the wheel were subjected to sudden extreme temperature changes, which of course are not likely in usual operation. Superheat "shoots" through a turbine under certain load conditions; but the wheels, diaphragms or shaft prob-

ably absorb an insignificant amount of it. Breaking of the vacuum will cause a more or less sudden change in temperature of the turbine rotor; but the writer does not at this time know of a case where damage or even minor trouble has come from this cause.

The 20th wheel, and presumably the others, has a tensile strength of 130,000 lb. and an elastic limit of 73,000 lb. per sq.in. It is 12 ft. 1 in. diameter, and its tip speed at 1500 r.p.m. is 950 ft. per second.

An engineer of unusual experience with turbines, who desires to remain anonymous, expressed his opinion that before these wheels would fracture or burst they would stretch so much as to become loose on the shaft and cease rotating at dangerous speed. Perhaps this would happen. But one wonders if the wheel would not rub the shaft, fuse both shaft and wheel, and freeze fast. It is recent experience, however, that in some cases of overspeed of turbine rotors, the wheels have been found loose on the shaft when examined after overspeeding occurred.

One wonders if these wheels in large-capacity turbines would ever, except under failure of both governors

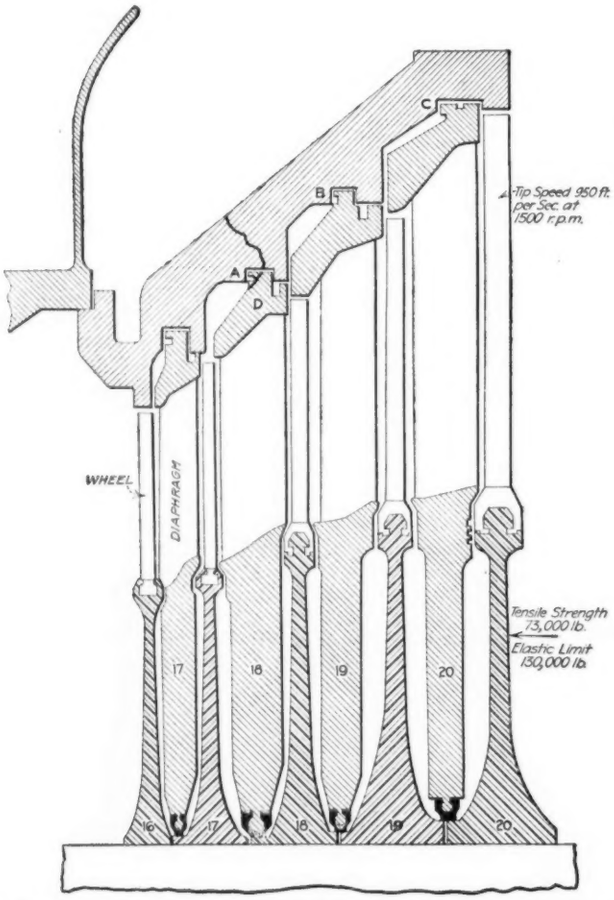


FIG. 6. SECTION OF LAST WHEELS AND DIAPHRAGMS TOGETHER WITH DIAPHRAGM SUPPORT FRAME. WHICH BROKE AS SHOWN

to function should all load be suddenly lost, reach a speed sufficient to fracture them. In the experiments by the engineering staff of the Public Service Electric Co. of New Jersey, conducted May, 1916, the last or final wheel of an 1800-r.p.m. 25,000-kw. turbine was about four hours being brought to a speed of nearly 3600 r.p.m., or to 198 per cent. of normal, and notwithstanding that a motor of 450 hp. was used to turn the wheel and that steam was impinged upon the blades to assist in revolving it. This gives one an idea of the windage of these wheels. The wheel in question did not fracture, and though painted and marked at

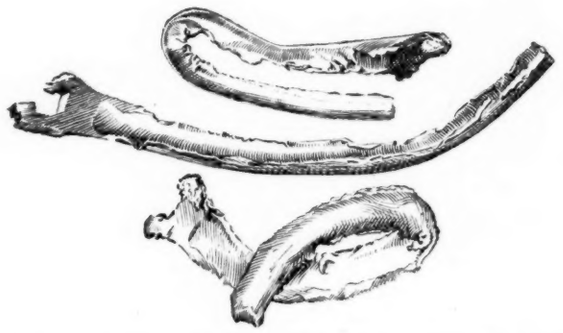


FIG. 7. TYPICAL BLADES FROM THE BOSTON TURBINE SKETCHED AFTER THE WRECK

the shaft and hub, showed no indications of having slipped or stretched.

The Boston wheel was certainly subjected to jamming and impact from broken blading and pieces released from diaphragms, and it withstood these severe shocks while subjected to the centrifugal force due to rotation at the normal speed. This demonstration of resistance is most assuring.

The machine was carrying 29 in. vacuum at the time the low-pressure end of the casing was blown out. Just what effect the sudden release of the vacuum had, one can study out at his leisure.

It is probable that steel will be used in the last stages of the Boston turbine when it is repaired. The builders are, of course, taking steps to avoid a repetition of this accident, and with their wide experience plus that gained in this accident, this should not be difficult, especially as no fundamental changes in design seem necessary.

It is likely that difficulties of manufacture of steel diaphragms as well, perhaps, as cost reasons account for the universal use of cast iron. In making diaphragms one large ring and one large disk, connected by nozzles or stationary buckets, have to be cast. The claim of some persons is that the steel nozzles would likely burn off or become seriously weakened if the disks and rings were cast of steel. However, by pouring and venting in a number of places burning of the nozzles where they join the ring and disk can probably be avoided.

When the Boston machine gets its new casing, the great web supporting the bearings at the generator end will be of steel for reasons of greater safety than cast iron insures.

The turbine with its condenser represented an investment of about $335,000.

The details of the accident described, some general observations are in order: Naturally, the question uppermost in the minds of designers and engineers is whether cast iron should or should not be used for large turbine diaphragm construction. This much is obvious: Cast iron should not be used where it is likely to be subjected to the stresses imposed by the centrifugal force that a steam-turbine diaphragm would

be called upon to resist if it revolved with the shaft. But this is the first case the writer knows of where a diaphragm has revolved with the shaft. Certain it is that if there are no probabilities of these large diaphragms being let down on the shaft, and if it is found that cast iron for these relatively thin disks is not subject to too great deflection, cast iron seems suitable, as the diaphragms now in use have a high factor of safety against rupture by normal stage pressure.

Since these high-capacity turbines, with their rotations which give wheel-tip speeds of nearly 1000 ft. per sec., have appeared, all have learned that rubbing of a diaphragm on its adjacent wheel and vice versa must be immediately stopped to avoid the loss of blading or more serious trouble. The element of time is most vital. Take the Boston case: If the throttle had been tripped at the first sign of serious rubbing or vibration, it is probable that the turbine would have needed nothing more than new buckets for the 18th wheel. To go further with the "if," for the good it may do "the next time she rubs hard," the casing would, in the Boston case, simply have had to be lifted off, the loose blades cleared away and the machine closed up and put back on the line—a delay, of course, but not a delay plus a direct loss of, say, $200,000.

The Human Side Must Not Be Neglected

The point is that turbine operators not only must be alert, sober and intelligent men, but must be made to realize that they should never take a narrow chance when the safe course is obvious and practicable. The watch engineer on the floor must know the peculiarities of his machines and have judgment quick and decisive enough to know when he should attempt adjustments to thrust bearing or governor, or whether he should signal for load reduction or trip the throttle. This is the human side of the development of turbine art. It must not be neglected, it must develop with the machine, for the machine is right and the human has the quality of adaptation.

Anyone not a switchboard operator would, when he looks at the scarred walls, the broken wire-glass in the switchboard gallery windows and the other turbines down the room at the O Street Station, turn over in his mind or revise his opinion as to placing turbines with their shafts transversely of the room. If the Boston machine had been placed transversely, the other turbines down the room might have been considerably damaged. There are excellent arguments for both transverse and longitudinal positions. The Boston case is an impressive one for the latter.

Just a word about turbine accidents in general. Some folks are foolish enough to try to give the impression that machines may be made, that they are made, so as to be "absolutely free from accident." No sensible engineer ever made such a statement. Be assured of that. Only the other day, in discussing this question with one of the most eminent turbine designers, a man to whom the world owes a deep debt of gratitude for his contribution to the art, he said: "The man who thinks this can be done is indeed foolish."

Accidents are as much a part of the progress in machine design as illness and death are parts of animal life. They are the impetus stimulants that reveal the danger zones and help us the sooner to get out of them.

Heat Carried to the Chimney by the Flue Gases

In a recent issue of the *Stevens Indicator* E. A. Uehling, M. E., derives the following formulas for determining the amount of heat carried off in the chimney gases.

CO = Percentage of CO in the flue gas;
CO_2 = Percentage of CO_2 in the flue gas;
H = Weight of available hydrogen per pound of carbon in fuel;
M = Weight of moisture in fuel per pound of carbon;
t = Temperature of air supplied for combustion;
T = Temperature of flue gases on leaving boiler;
V = Weight of water vapor in the air used to burn one pound of carbon;
W = Weight of water of hydration (water combined in fuel) per pound of carbon.

H is the weight of free hydrogen available for combustion per pound of carbon as distinct from the hydrogen already combined with oxygen and forming the moisture and the water of hydration in the fuel. W is the weight of water $\left(O + \frac{O}{8}\right)$ that is formed by the combination of the oxygen, O, in the fuel per pound of carbon with hydrogen, in which form it is combined in the fuel as water of hydration as distinct from the moisture which is present but uncombined.

Heat Carried Away by the Dry Gases

$$\left(0.24 + \frac{58.46}{CO_2}\right) \times (T - t)$$

Heat Carried Away Through Incomplete Combustion

$$\frac{10{,}150 \times CO}{CO + CO_2} + \text{other combustibles difficult to determine and generally negligible}$$

Heat Carried Away by Water Vapor in the Air

$$V \times \left(\frac{117}{CO_2} + 3.8H\right) \times (T - t)$$

Heat Carried Away by the H_2O from the Combustion of Hydrogen

$$4.32 \times H \times (T - t)$$

Heat Carried Away by the Moisture and Water of Hydration in the Fuel

$$(M + W) \times (0.48 \times T + 1080 - t)$$

Theoretical Maximum CO_2 Obtainable from Fuel Containing Hydrogen

$$\frac{21}{1 + 2.38H}$$

Percentage of Excess Air Supplied

$$\frac{2100}{CO_2(1 + 3H)} - \frac{100 + 238H}{1 + 3H}$$

Percentage of Oxygen in Gas

$$21 - (1 + 2.38H)\ CO_2$$

Be careful that no pieces of rubber gaskets work through the steam pipe into the steam chest of a throttling engine. Wrecks have occurred due to the governor valve being blocked open by pieces of packing.

Training Power-Plant Men for the Navy

By WILLARD CONNELY, U. S. N. R. F.

How ship fitters and gas engineers get expert free training for duty with Uncle Sam's fleets.

NOT all the naval pipefitters, steam and gas engineers, water tenders and boiler men can be trained at sea. There is neither room nor time for that. Schools of instruction on our coasts and inland, too, are adding more and more men to their classes every day. Quite as frequently the raw recruits of four months back pass their examinations at these training stations and are dispatched with all speed to their receiving ships, whose power rooms the new bluejackets enter familiarly, chafing for action.

A school's remoteness from the ocean does not deter the Navy Department from authorizing thereat trade instruction for bluejackets. For instance, witness the training base established at Dunwoody Industrial Institute, Minneapolis, now producing for the fleets nearly three thousand artisan specialists a year.

Dunwoody Institute is a free trade school, and although the Navy now makes demands on the major portion of its facilities, it continues to hold civilian classes in day, evening and extension courses. Of the ten departments now making dextrous naval craftsmen out of bluejacket apprentices, among the foremost are those teaching the foundry and boiler men, the pipefitters, and the gas, steam and oil engineers. Three general divisions of power-plant processes are here involved: Navy blacksmiths in a power plant would do the repairing, metal workers would make new parts, navy gas engineers would represent operation. The naval detachment, under the command of Ensign Colby Dodge, U. S. N., has now a smoothly running routine worked out by the commandant and by Acting Director Kavel of the Institute.

Work in Forging and Welding

The blacksmithing and boiler men begin naturally at the forge. Preliminary exercises involve making various foundry tools, then a week or two building iron racks and the like, and the blacksmiths come to the most significant branch of their course—oxyacetylene welding. At the welding tables the bluejackets repair broken or cracked machine parts. They are dentists to stripped gears. They rebuild a cylinder, a cam or an engine connecting-rod. All this time the ironworkers are having daily classroom work too, in heat treatment of metals, metallography, and related mathematics. Open discussion is encouraged, that the older jackies who have been previously at the trade may relate their power-plant experiences.

The men are admitted to the Soo line car shops in St. Paul, where they tackle welding jobs so comparatively gigantic that nothing thereafter on a battleship will seem too formidable. From a motor-boat engine cylinder to the stripped boiler of a big freight locomotive is a significant leap. After two months in the car foundries the naval apprentices rightly believe themselves to have become fairly competent welders. While acquiring skill at the Soo shops, the blacksmiths alternate training periods in the boiler room at Dunwoody, where at stated hours they assume the responsibility of the boiler operation. This duty they share with men in other departments also, men whose general scheme of training covers a survey of power-house methods. Four to five months, in sum, round out a man in the foregoing vocation, whereupon he goes aboard ship.

Power-plant men will see at once that the instruction of these metal-worker bluejackets is essentially in productive work.

The course in pipe fitting, which embraces training in coppersmithing, tinsmithing, sheet- and galvanized-iron construction, covers mathematics through solid geometry, catalog study, freehand sketching and laying out of water, vapor and low-pressure heating systems, plan reading and estimating quantities.

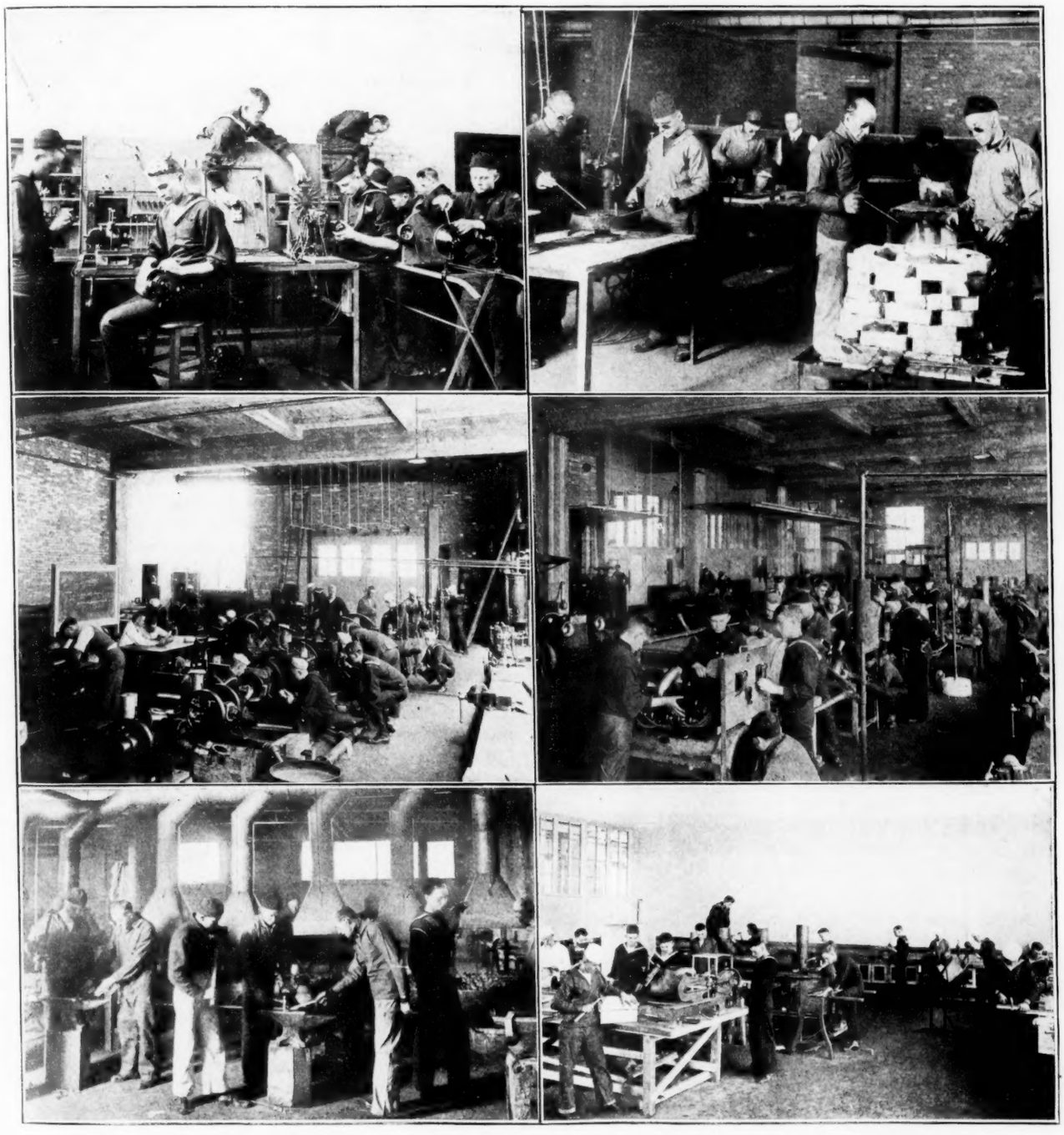
Gas-Engine Instruction

Outfitted at the start with a set of hand tools and all the standard coppersmith stakes, the bluejackets in the power-plant course are then acquainted with the crimping machine, the bar folder for stovepipe, the cornice brake to bend up edges, the squaring and circle shears, and rolls for forming. Working in tin, the students make mess pans, dust pans, drinking cups, cooking measures and funnels; then they proceed to such marine articles as tees, elbows, bunker lamps and ventilators. While such power-house accessories as oil cans, oil feeders, air chambers and ventilators are made of copper, the more important exercises allied to pipe fitting comprise a cuff joint, a cramped-seam pipe, a long bend, short bend, return and offset bends, a formed tee, and single and double saddle branches.

Through the naval students' gas-engine class at Dunwoody lies the quickest avenue for a recruit to attain the rating of a chief petty officer. This exigency is created by the sudden demand of the Government for experienced gas-engine men to make up the engineer crews of the new submarine chasers. Now that enlistments in the Navy are closed to men of draft age (unless their numbers are obviously far down the list), perhaps the best chance remains for engineers between between 31 and 35 years old, because of their more substantial knowledge of the craft. However, competent men between 18 and 21 are gladly enrolled in this course. The point is, a man who enlists as seaman for training in the submarine-chaser corps can in four months arrive at the rating of chief machinist's mate, provided he knows what he knows. This chance cannot be duplicated, nor will it last for long.

To be sure, not all Dunwoody gas-engine apprentices are pointing for the submarine-chaser service. Some of the bluejackets cannot make all the requirements, which embody a proven ability to handle men and to stand the shaking of the high seas in a small boat. Gas-engine students not so qualified are trained for motor-boat pilots, operating the boats that ply between

ships of a fleet or from a ship out in the harbor to shore. On a basis of five days' instruction per week, with Saturday mornings for review and tests, the gas-engine men spend three half-days in the Dunwoody auto shop, tearing down, repairing and reassembling gasoline engines, three quarter-days with classwork on theory of engines and starting and lighting, three quarter-days in the testing laboratory, operating oil and steam launch engines, taking horsepower tests, setting valves and taking indicator cards. The remaining four half-days have been employed at a near-by lake, running motor boats and learning to approach docks properly. Through the winter the boat work is indoors, overhauling and repairing parts. The auto shop is fitted with gas engines of various types from one to twelve cylinders, with axles and transmissions of equivalent diversity. The ignition room has an electric dynamometer for testing horsepower, with a profusion of carburetors, magnetos, starting and lighting systems.



ENGINEER STUDENTS IN TRAINING FOR SERVICE ABOARD SUBMARINE CHASERS

For a comprehensive idea of this highly developed course, a résumé of the work from week to week may be taken. First the men are given classroom lectures on engine types. They make a study of the basic principles of these types, including both two- and four-stroke-cycle kinds, and a survey of general construction and arrangement of parts. The crank case and attached

parts are next taken up. This subject covers bearings, crankshafts, flywheels, counterbalancing and connecting-rods. The third week is devoted to cylinder parts, their assembly and correct fitting, concluding with observations on pistons and rings, the whole covering both two- and four-stroke-cycle cylinders. Valves, springs and timing follow, and their correlative subjects of camshafts and timing gears.

Cooling systems claim the fifth week, during which pumps and piping of all recognized sorts are analyzed and examined. The natural corrollary of this topic is lubrication. A description of each lubricating system is necessary, involving questions and answers on oils and their distinguishing characteristics. The seventh week is given to carburetion, under these heads: Fuels and their uses, mixing valves, carburetor types, fuel tanks, piping systems, manifolds, mufflers, inlet, exhaust, cutouts.

By this time the bluejackets are required to apply their knowledge directly to the operation of the Norfolk Navy Yard engine for a week, and then to the Van Blerck engine. On both these highly important pieces of naval machinery each sailor is examined, asked to describe all parts discussed and studied to date.

Three weeks are given to the subject of ignition, covering a description of systems, wiring, coils, interrupters and distributors, magnetos and generators. Two weeks more are taken up with starting and lighting, in the same department. Generators and motors, wiring and cutouts, storage batteries and lights are the subdivisions of this period. Then comes a week of transmission systems with instruction in gear sets, reverse gears, thrust bearings, propeller shaft and propeller.

Oil engines are considered separately. Five days' intensive application to this type is given, with horsepower tests and valve notations, so that by this time the bluejacket is familiar with every kind of engine in wide use—gas, steam or oil. Finishing training succeeds on the Norfolk and Van Blerck types, with a study of all features not previously inspected.

The final teaching period is occupied with boat construction. A bluejacket who knows how to run a motor boat should also know how to build and repair. In the gas-engine class he winds up with learning displacement theory, hull construction, engine mounting, control and signals.

As fast as the bluejackets can complete this course satisfactorily they are sent to receiving ships or transferred to Columbia University for a four weeks' supplementary training on actual submarine-chaser apparatus. The time required by the average student in gas-engine work at Dunwoody is four to five months. At the school of mechanical engineering at Columbia the sailors have a week in the electrical laboratory, a week in the mechanical laboratory and two weeks of outside training under the supervision of instructors. The first week of outside work is in the assembly department of a chaser yard somewhere on the Atlantic coast, and the final week before going to sea is spent studying the engine itself in the process of manufacture.

Before a gas engineer is recommended for transfer to Columbia he must pass a rigid personal examination, aside from his technical test, by Ensign Dodge. Two companies of Dunwoody men have qualified and are now at sea.

Anthracite Coal from Lignite

By Charles Philip Norton

A lawyer named Fiske, whose standing and connections command respect, startled the Seattle public in February by announcing that after years of experimentation he had perfected a system of coal distillation by which the full power value of lignites could be utilized, saving the byproducts of gas, coal tar and oils and producing a manufactured coal containing seven-eighths of the fuel value of the best Pennsylvania anthracite. In the process of making coke from bituminous coal the byproducts are saved to some extent, but anthracite coal goes to market untreated.

Mr. Fiske said he had no stock to sell, no scheme to promote. In proof of his patriotism he proffered his formulas to Franklin K. Lane, Secretary of the Interior, for the use of the Government. Together with his offer to Secretary Lane, Mr. Fiske urged that the Government appropriate $500,000 and establish the first coal-manufacturing plant, utilizing lignites, with a capacity of 100,000 tons per annum. The volume of byproducts, he said, would be enormous and profitable. He guaranteed that the coal manufactured by his process from the practically worthless lignites would be almost as good as the best anthracite and that it would stand every test in use.

Mr. Fiske is a man of independent means. He said that if he desired to make a fortune he would engage in such manufacture upon a colossal scale and in a few years would rank with Rockefeller, but that his sole desire at this time was to "swat the Kaiser." "It is almost a crime, in my opinion," said Mr. Fiske, "to waste the byproducts in coal—products which we need so badly in everyday life."

The Fiske manufactured coal is not even second cousin to the well-known briquet, according to his statement. The latter, he says, simply is coal in a different form, containing all the byproduct elements, while his coal is divested of these products *in toto*. He further says:

> If the Government is afraid to experiment with my process, but will appropriate the necessary capital for the initial plant, I would be perfectly willing to operate the plant upon a lease and commercial basis, paying the Government 7 per cent. on the investment, and would put up a bond in any amount to guarantee the Government against possibility of loss. Being a Westerner, believing in immediate action in a matter so vital as this, which promises permanent insurance against coal famine as well as a never-ending supply of the valuable byproducts of coal, I am urging the Government to do it now.

In almost every Western State and in Northwestern Canada there are vast deposits of lignite coal which is undesirable as fuel in its natural state. Mr. Fiske is of the opinion that the United States should lead in coal distillation. He says:

> It is no secret process, but is well known to scientists and power engineers the world over. The stupidity of governments is such, however, that none has yet started this industry. Once begun, it will develop rapidly into a colossal enterprise. Large capital is required to get immediate results. That's why I am anxious to have the Government take hold of it.

He said his process and formulas were the result of many years of scientific study and experimentation; that he was willing to make a gift of the whole thing to Uncle Sam, provided the Government would use it to help win the war.

Warrior Steam Plant of the Alabama Power Company

By W. B. WEST

A stand-by steam station to be held for taking care of emergency loads. There is but one 25,000-kw. turbo-generator unit, the largest in the South. Two additional units are to be installed. Coal is obtained from a mine but a few hundred feet distant.

PRIOR to August, 1917, the Alabama Power Co., operating in North Alabama, with headquarters at Birmingham, generated most of its power at Lock No. 12 on the Coosa River, thirty miles below Birmingham, and had but a 10,000-kw. steam plant in reserve. This plant is at East Gadsden, Ala.[1] At Lock No. 12 there are five 13,500-kw. vertical waterwheel generators. When the river gets low, these generators cannot carry the load, and it was seen that the East Gadsden plant would soon be too small to take care of an emergency. The company officials, therefore, decided to construct another steam plant on the banks of the Warrior River (Fig. 1) about forty miles northwest of Birmingham, to be held in reserve. By the time the first unit in this plant was started, the load in the Birmingham district, at Gadsden and at Anniston, had become so heavy as to make it necessary to put it into operation at once.

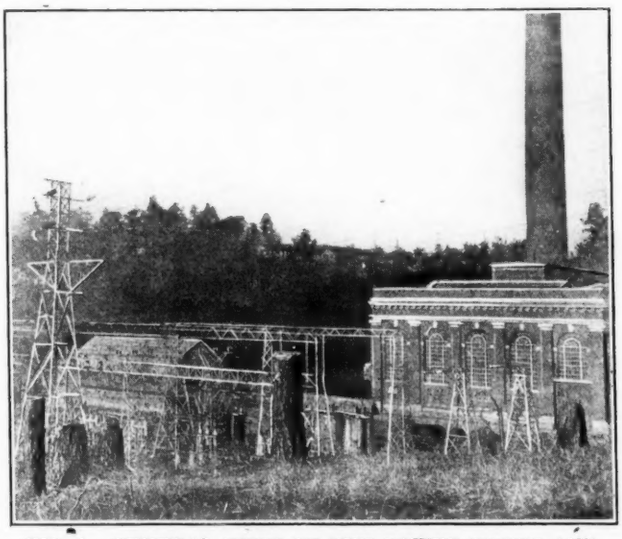


FIG. 1. GENERAL VIEW OF THE POWER HOUSE AND SUBSTATION

Since that time the Government has decided to use power generated at this plant for the operation of its industries at Muscle Shoals on the Tennessee River (Near Sheffield, Ala.) until the $12,000,000 dam at that place is completed. Construction crews are hastening the completion of the transmission line. The power plant to serve the Government projects will be enlarged and extended at an initial cost of $3,000,000. The size of the new units to be installed has not yet been determined. It is certain, however, that they will have a capacity of over 25,000 kv.-a. each.

It is interesting to note that the Warrior River plant is at an apex of a large imaginary triangle whose sides inclose the Birmingham district. Lock No. 12 is at another apex, and the East Gadsden plant is at the third. While most of the load is still carried by the Lock No. 12 plant, it is necessary to keep the Warrior River plant in operation except during periods of high water on the Coosa River.

The location of the new plant was determined largely by the available supply of coal and water. Ground was broken early in July, 1916, and in spite of the congested freight situation and manufacturing delays, the first unit was started in August, 1917. While not a record performance, yet in view of the fact that the main equipment was much delayed, it compares well with similar installations even in the less active periods.

In general plan the plant follows pretty well the established practice for an installation of its size. The foun-

[1] See "Power," p. 156, Aug. 4, 1914.

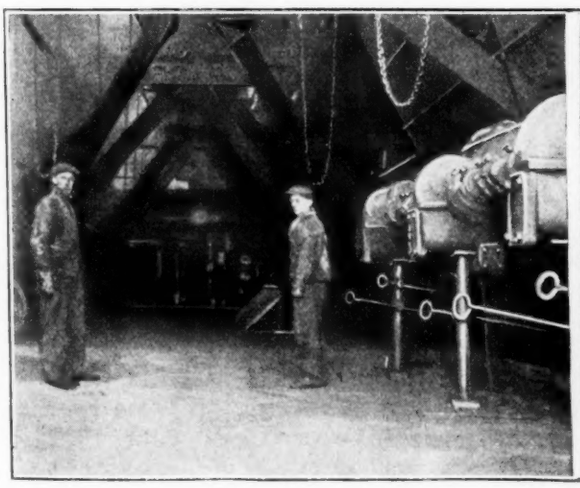


FIG. 2. BOILER ROOM AND AUTOMATIC STOKERS

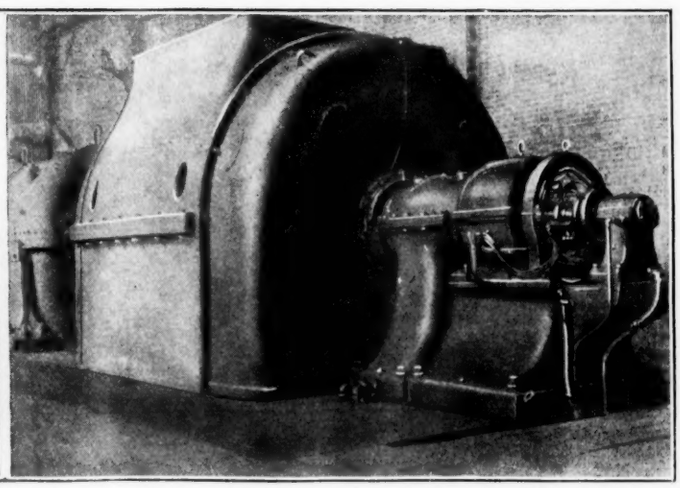


FIG. 3. THE EXCITER END OF THE MAIN GENERATOR

dations are carried down to bedrock, which lies fairly level about fourteen feet below grade. The basement walls of the turbine room and the walls of the cold well are carried down to rock, which is below the river-water level; but in the boiler room the columns are carried on piers founded on rock.

The boiler room at present is 86 x 120 ft. in the clear and accommodates six water-tube boilers, Fig. 2, each

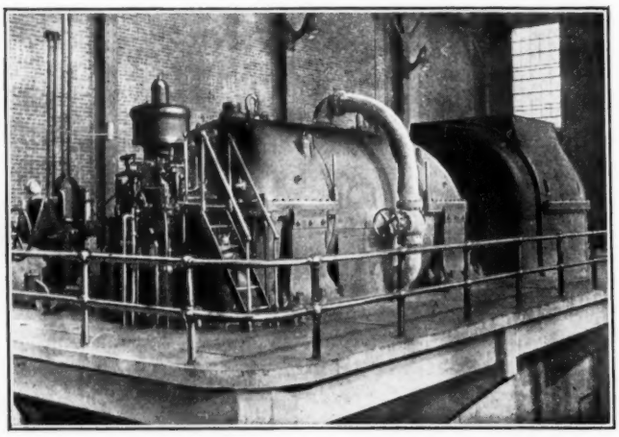


FIG. 4. THE 25,000 KV.-A. TURBO-GENERATOR

of 1200 normal horsepower with 150 deg. superheat. Five of the stokers are the underfeed tuyere type. All are driven by two stoker engines.

The fact that coal is mined only a few hundred yards up the river from the plant is one of its interesting features. The plan of establishing a power plant at the mouth of a coal mine has been advocated by many of the leading engineers, but as yet very few plants have been so located. After it leaves the mines the coal is carried to the crusher in cars drawn by electric locomotive. From the crusher it is delivered upon a 24-in. belt conveyor driven from the lower end. The belt conveyor discharges into a steel bunker having a capacity of 600 tons. From the bunker the coal passes into the automatic registering scales. Each stoker is equipped with two sets of scales. The total weighing capacity of the twelve scales is 9600 lb. per min. Ordinarily, the daily coal consumption is about 450 tons.

At present the turbine room is 40 x 86 ft. in the clear and is served by a 60-ton overhead crane. In order to make room for the two additional units that are to be installed at once for the Government, the turbine room will be enlarged to 258 x 40 ft. Another crane, larger than the one in use at present, will also be installed in the near future.

At present there is one 25,000-kw.-a., turbo-generator served by a jet condenser located in the basement (see Fig. 4). Circulating water is pumped from the river and goes back by force of gravity. The generator is cooled by means of a water-driven blower located in the basement.

Water for boiler feed is drawn either from the discharge or from the intake canal and is measured by venturi meters. Centrifugal feed pumps are used. The boiler piping follows the usual lines.

The generator is equipped with a direct-connected exciter, Fig. 3. There is also a motor-generator exciter set and a turbine-driven exciter. The latter supplies power to haul coal from the mines to the plant. It is a 100-kw. 230-volt machine, making 3600 r.p.m. The main generator speed is 1800 r.p.m. The current is three-phase 60-cycle generated at 6600 volts and is stepped up to 45,000 volts for distribution. The switching system consists of duplicate busses with remote-controlled solenoid-operated oil switches. The feeder circuits are equipped with three-phase aluminum-cell lightning arresters.

The installation was designed and constructed by the company's engineers and construction department, O. G. Thorlow, chief engineer, and J. A. Sernit, chief electrical engineer having charge of the work. A. R. Gilchrist is in charge of construction.

Speed-Reduction Gear

Small steam turbines and electric motors to be cheap and efficient must run at a higher speed than the machinery which they drive. Reciprocating engines, on the other hand, often run much slower than the generators, fans, pumps, etc., for which they furnish power. To step the speed of the prime mover up or down to meet the requirements of the driven apparatus is a problem which the engineer must often solve.

The ideal thing would be a self-contained device which could be inserted in the shaft connecting the prime mover with the load and which would receive the power at the motor speed on one side and deliver it at the desired speed on the other. Such a device is the Turbo-Gear, shown in Fig. 1, and manufactured by the Poole

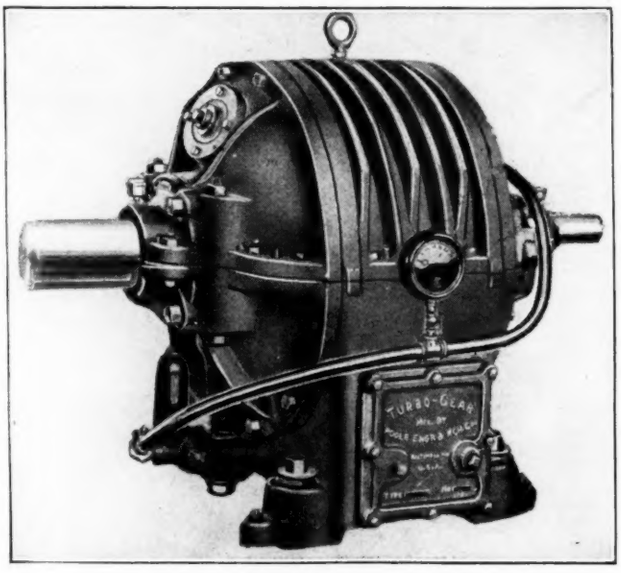


FIG. 1. EXTERIOR OF THE TURBO-GEAR

Engineering and Machine Co., of Woodberry, Baltimore, Md. If the speed is to be stepped down, the swiftly running motor or turbine is connected to the smaller shaft at the right, and the larger shaft, in the same axial line at the left, rotates in the same direction at the desired speed. If the speed is to be stepped up, the prime mover is connected to the larger shaft.

The method by which the change is effected is shown in Fig. 2. If the shafts or pins upon which the intermediate or planet gears *C* turn, were held in a fixed

position, it is apparent that if the internal gear *A* were rotated counterclockwise it would rotate each of the intermediate gears *C* counterclockwise upon its own axis and these would drive the pinion *B* in a clockwise direction. But suppose the internal gear *A* to be held stationary and the planet gears *C* to be mounted in a carrier, Fig. 3, free to turn upon its axis. If now the pinion *B* is revolved in a clockwise direction, it will turn the gears *C* each upon its own axis in a counterclockwise direction, but they will roll around upon the internal gear *A*, carrying the cage which supports their

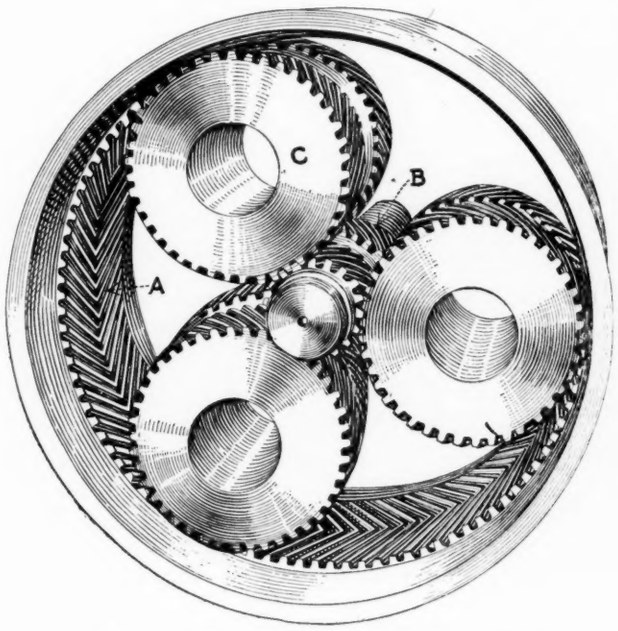


FIG. 2. DETAILS OF THE GEAR MEMBER

axes, and the shaft to which it is attached, around in a clockwise direction, like the actuating pinion.

The assembled mechanism is shown in longitudinal and cross-section in Fig. 4. The pinion shaft is supported at the left in a ring-oiled bearing, and at the right its reduced end is carried in a bronze bushing in the axis of the low-speed shaft. The low-speed member is supported on both sides of the gears by ball bearings.

An eccentric on the low-speed shaft within the casing actuates the plunger of a pump by which oil is forced to all the bearings and gear faces through the channels shown. This oil gravitates back to a chamber in the base containing a cooling coil, from which chamber the cooled oil is taken by the pump through a filter.

The change in speed depends upon the ratio of the pinion to the large internal gear, the intermediates or planet gears being simply carriers. The gear must be designed with reference not only to the change in speed, but to the load to be transmitted and to the actual as well as the relative speeds. As an indication of the

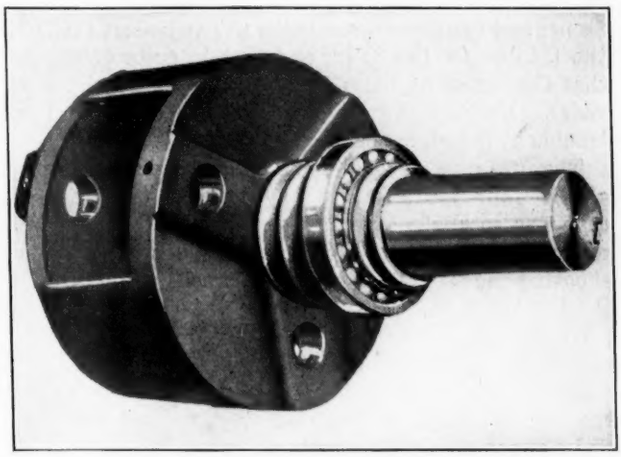


FIG. 3. THE CARRIER AND SLOW-SPEED BEARING

range of speeds and horsepower capacity offered, the following data are given relative to five types of Turbo-Gears:

Type A, with 24 separate ratios from 4 : 1 to 7 : 1, good for from 1 to 50 hp.;
Type B, with 51 separate ratios from 4 : 1 to 10 : 1, good for from 1 to 130 hp.;
Type C, with 71 separate ratios from 4 : 1 to 13 : 1, good for from 1 to 240 hp.;
Type D, with 105 separate ratios from 4 : 1 to 19 : 1, good for from 1 to 400 hp.;
Type E, with 135 separate ratios from 4 : 1 to 17 : 1, good for from 1 to 800 hp.;

The Poole company is, however, able to furnish gears capable of transmitting any load up to 20,000 hp. with speed ratios varying from 4 : 1 up, which ought to meet any case likely to occur in ordinary practice.

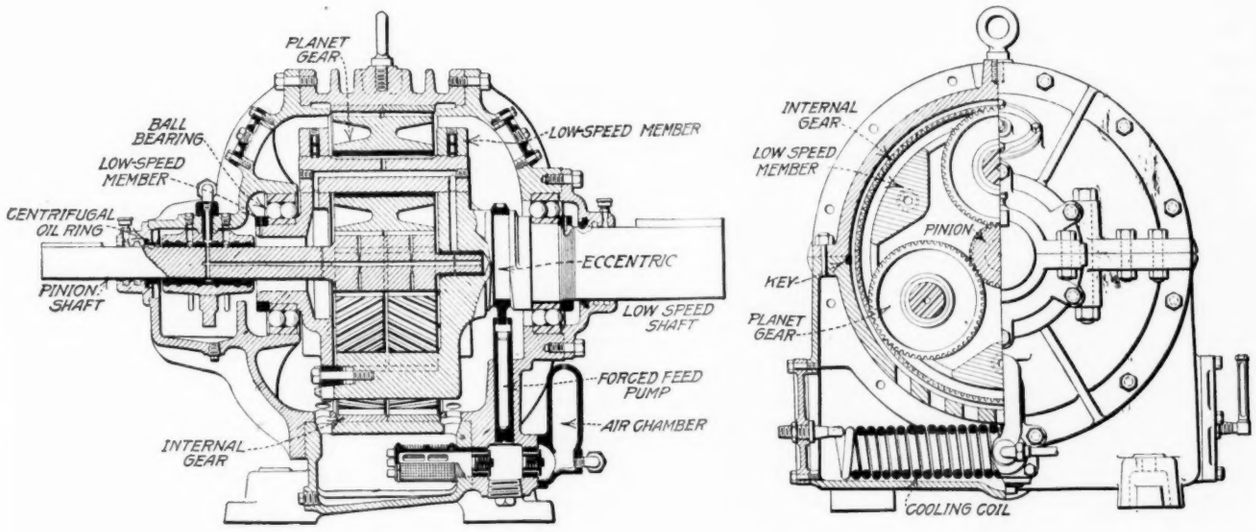


FIG. 4. LONGITUDINAL AND TRANSVERSE CROSS-SECTION OF THE TURBO GEAR

Electric Welding Stops Leaks in Girth Seams

By ROMEO A. GRISE

To engineers who have experienced trouble with leaks in the first girth seam of return-tubular boilers, the following is of interest. The trouble referred to in this article is leakage due to fire-cracks at the seam over the fire.

IN THE plant to which this article refers there are five 84-in. return-tubular boilers with overhanging fronts, nine 72-in. return-tubular boilers with flush fronts and two water-tube boilers. The boilers that gave the trouble are the 84-in. and that in spite of the fact that the oldest of these five has been in service seven years. None of the other boilers has ever given any trouble at the girth seams.

The first of the troublesome boilers had been in place almost four years before any leakage occurred, and that was so slight at first that when new boilers were needed for extensions it did not influence us against choosing the same type. The fire-cracks through which the leakage passed appeared from the rivet hole to the calking edge. At first only a few were noticed, but as time wore on it was not surprising to find twelve to sixteen cracks on one boiler extending from a point over the fire to about one-quarter way around the shell. Some of the cracks were from one rivet hole to another. Pieces of the plate actually fell out while the boilermakers were calking the edge.

Cause of Leaks Perplexing

The cause of the trouble puzzled us all. Some said it was due to the water; but if that was so, why did we not also have trouble with the 72-in. boilers? One thing seems certain, and that is, the thickness of the metal from which the shell was made had some influence. These boilers are made of $\frac{5}{8}$-in. plate, while the 72-in. boilers are of $\frac{9}{16}$-in. plate. The extra thickness makes some difference when the plate is over a very hot fire, but beyond the possibility of thick plate no one here offers a good reason for the trouble. The material used in making these boilers was not necessarily poor, because all boilers gave the same trouble and no two of them were built at the same time. We do not believe that mud or oil was to blame for the fire-cracks; for while there was just a trace of oil and a little mud did collect in the bottom of the boilers, the same conditions were true for the 72-in. boilers.

It was finally realized that just plain calking would not stop the leaks. It was then decided to try oxyacetylene welding.

The way this was first tried was to weld the plates together solid along the calking edge; but this did not hold, as on absorbing the heat the inside plate would curl up and away from the lap and the weld would break almost immediately. In one joint the strain caused by the cooling of the weld pulled the rivets apart. Then it was decided to take out the rivets where the fire-cracks occurred, "V" out these cracks, weld the plate back to normal again and scarf the edge. After the plate was welded, the rivet holes on the welded plate were drilled and the boiler again riveted just as in the shop. This job seemed to give satisfaction, and the remaining four boilers were similarly repaired. The first boiler ran about six months before it started to leak again, but the other four lasted only a short time; one of them, the last one repaired, held hardly two weeks.

About this time forced draft was used under these boilers, a fact which doubtless did not better conditions, as the fire in the furnace was almost white hot. Still, forced draft was not the cause of the boilers leaking again.

For the next five months we were trying to keep going as best we could. The load was quite heavy, the coal very bad and the draft poor. Those boilers would leak so badly that when the men came on in the morning, there would be a large area on the grates where the fire was dead and the fuel bed water-soaked. Some of the boilers had two or three streams the size of a lead pencil pouring down on the fire. Imagine trying to get up steam under those conditions. It was necessary to have boilermakers on the job every two or three weeks to calk the cracks.

The Electric Welder Is Called In

Finally we got in touch with electric welders who would tackle most any kind of a job and guarantee it to hold. The guarantee was something new to us as the oxyacetylene people would not guarantee their work. As a last resort we decided to give these electric welders a trial. We had everything to gain and nothing to lose; the condition of the boilers meant patching each one of them and possibly having the pressure cut down by the insurance company. And a patch would expose two seams to the fire instead of one, which presented the possibility of twice the trouble and of eventually compelling us to throw out the boilers.

When the electric welder arrived, we had our worst boiler out for him. He looked it over carefully and asked a few questions, then calmly told us he could fix the boiler so it would be tight and would give us a three-year written guarantee. He also gave us as references the owners of two large power plants where he had done similar work. We wrote these people and received encouraging replies.

The process of electric welding required that first the boilermaker chip away all the old stock on the outside of the girth seam till clean metal was reached. When he had chipped away all that was necessary, the welder built up new stock on the plate, bringing it up to its original length and thickness. At the same time that the plate was being built up, it was welded to the other plate at the lap, and when the calking edge was reached the whole seam was welded together.

Where there was much new stock to build up, it was necessary for the boilermaker to chip off the scale of each "layer" as it was applied by the welder. The loose rivets were also welded to the plate without being removed, it being necessary only to chip all around the heads.

For electric power the welder used our regular 110-volt direct current with about 50 amperes. The volt-

age was cut down to about 20 through a water rheostat. One side of the line was grounded at the switchboard so that the boiler proper formed the other side. On an average job it took the welder between 12 and 14 hours to weld six feet of girth seam.

After this boiler was finished and satisfactorily passed the scrutinizing inspector of the insurance company, we waited a couple of weeks for developments. As the job, however, appeared to hold well and to be as good as guaranteed, we decided to have the remaining four boilers welded.

It is now more than four months since the first boiler was welded, and all five look as good and are as tight as the day they were finished. We feel pretty certain that the welding will hold for the three years and longer.

In the opinion of the writer the success of this job over the oxyacetylene is due to two facts. One is that with oxyacetylene welding the metal is heated over a large area and consequently there are strains when the metal is cooling. In the electric welding the heat is localized with little or no attendant strains due to cooling of the material.

The success of this welding is due also, I believe, to the man doing the work. He must know how to do a first-class job and must use good judgment both as to the amount of stock to be chipped away before he starts welding and as to the thickness of stock applied on each "layer" as he is building upon the old plate.

Maintenance of Electric Elevators

By CHARLES W. NAYLOR
Chief Engineer, Marshall Field & Co., Chicago, Member A. S. M. E.

Cable and brake troubles, iron vs. steel ropes, governor cables, the need of lubrication and kilowatt-hour consumption per car-mile of electric elevators are discussed.

CABLES, as the wire lifting ropes of elevators are called, are the source of one of the two chief elevator troubles. The substitution of steel for iron ropes, which has come about during the last twenty years, has added greatly to the worries of maintenance engineers, for the change has not brought with it all that might be wished for. The more recent machines, with their higher speeds and greater loads, naturally led to the use of new materials without necessarily adding to their reliability. The increased cost of renewals accompanying the use of steel cables is almost enough to condemn them. If the operator would be satisfied to put up with the troublesome stretch of iron ropes, he would be tempted to use them exclusively, but excessive stretching or lengthening of the cables has to be equalized by frequent and tedious readjustments of the limit stops and the compensating devices, particularly where there is only a small overtravel space at the top and bottom of the hatchway. When it is considered that these adjustments must be made for both the car and the counterweights as well as for compensating weights or chains, the engineer will often ask himself, Does it pay?

The harder and stiffer a rope, provided it is flexible enough to suit the carrying sheaves or drums, the more rapidly it crystallizes and breaks. A good quality of iron rope and perhaps a soft-steel cable, may run four or five years on a traction machine, while a hard-steel cable will need replacing in two years or less on account of its greater brittleness. This defect is intensified by the manufacturer making the ropes too hard on the pretense that great strength is needed. This applies equally to all makes of rope.

In spite of the utmost precaution no manufacturer is certain that two batches of rope of the same catalog grade will act alike in service. At any rate the engineer using them knows it by the cost to his employer for renewals. Breakage is liable to occur at any point of the cable running over the drums.

There is another break, which occurs at the shackles on top of the car. It is caused by the flection produced by the cables swinging from side to side. The severe changing torsion set up at this point, because of the tendency of the cable to unwind and rewind on itself due to the set given it when built in the factory, also contributes to the stress at this point. The set in the cable is disturbed by the frequent and great changes in load that accompany the starting and stopping of the car. The strain runs from zero to several thousand pounds and may take place a number of times in each minute that the machine is in operation. The ball-bearing swivel shackle is intended to obviate this trouble, and is successful to a considerable degree.

If a cable runs many years, as was common in the use of elevators years ago, the inner strand will frequently crumble and be broken in small pieces, the cause being largely a lack of interior lubrication in the cable itself. If cables are in use less than three years under average operating conditions, and run in a warm, dry place over generously proportioned drums having a diameter of 60 to 1 for the rope, the lubricant put in the cables by the manufacturer will be sufficient to prevent this cracking. If the life of the cables exceeds this period, and particularly when the cables travel over small sheaves, if the former is of hard material and is used in a cold and damp place, frequent lubrication is necessary. A good penetrating oil or liquid grease is best for this purpose.

Governor ropes or cables are made of vegetable fiber like hemp or cotton and of steel or iron. They are naturally more flexible than the lifting ropes, but have troubles similar to the larger cables although to a lesser degree. They require internal lubrication only when run in damp places and when in use for unusually long periods. A record kept on manila governor ropes for 15 elevators shows a wearing-out or breaking period varying between 14 and 56 months, with an average life of 37 months.

The second cause of serious trouble in an electric elevator is the brake—and these two troubles, cable and brake, are of more moment than all others combined.

An elevator brake, in many installations, is applied many thousand times every day and must bring a high-speed 40- to 50-hp. motor and a fast-moving elevator car weighing 6000 to 8000 lb. to rest and hold it each time the car is stopped. Of course it is helped to some extent by the dynamic-braking action of the motor, but the real stopping is done by the brake itself. Since the brake has to act so frequently and positively, it must act through a small space, which minimizes the opportunities for adjustments. In fact, it is an extremely difficult task to adjust a brake so that it will work equally well on up and down travel, and particularly with temperature changes that come with frequent use. Brake bands and their lining and the brake wheels or drums, become hot on severe service, rising 75 or 100 deg. F. above the temperature of the surrounding atmosphere.

The lining of the brake band, on which the brunt of the work falls, gives the most trouble. No really good substitute for the usual leather lining has been found, although a number of asbestos and fibrous compounds have been given trials. The old-style wooden blocks with the grain end on did not prove satisfactory.

A brake must set itself smoothly, not too suddenly, and with certainty. Brake slippage, if not too serious, may be anticipated by the skilled operator, except at the top and bottom landing, where there is small pit space. A car must come to the top and bottom landings at normal speed, as otherwise the automatic limit stops interfere with the car reaching the floor.

A good brake lining in easy service may last for years, but in heavy work only a few months. The leathers must be solid and clear of hard spots. Built-up leather in which glue or cement is used, will not last long enough to justify giving it a trial.

Calculating the Energy Consumption

The energy consumption in kilowatt-hours per mile of car travel is best obtained by taking the total readings over a period of not less than eight hours. An ordinary recording watt-hour meter and a revolution counter attached to the main drum or sheave will answer the purpose nicely. The counter must not be attached to the drum periphery, because the speed, often 400 to 500 ft. per min. is too great. A good place to connect on the counter is at the small chain operating the signal lights, if this latter device is used.

There is a movement of the car at the end of its travel that is too small to register a full unit on the counter, but this is absorbed in the total travel when the test is extended over several hours. It is seldom that the recorded revolutions of the counter match evenly with the cable travel, so that a constant must be found and used in multiplying the revolutions to give a correct product in feet or miles.

As explained in a previous article ("Operating Costs of Electric Elevators," Feb. 5 issue) the plant in question contains 91 elevators, 77 being used for passenger service and 14 for freight. Fifty of the passenger cars are of the worm-gear overhead drum type. The others are traction elevators, a few being of the basement type.

The drum machines run 11 to 15 miles per day and the traction elevators, 16 to 20 miles each. The energy consumption of the drum-type elevators is 3.5 to 5.5 kw.-hr. per mile of car travel. No two cars out of the 50 under discussion use exactly the same amount of current, except by accident, and any one car will register differently from one day to another, but the average for any ten cars taken at random, is 4.55 kw.-hr. per car-mile. For the traction machines it is 4.25 kw.-hr. per car-mile. The car speed per minute is greater in the case of the traction machines, but the cars are smaller and lighter. The drum-machine motors are rated at 42 hp. and run at 700 and 850 r.p.m., while the traction-machine motors are 35 hp. at 60 to 65 revolutions.

In a working plant it is not convenient to get the comparative records for up and down travel, and when varying loads in both directions are taken into consideration, there is no good reason for assuming any difference. In the plant under discussion about 40 cars are operated on the basis of 20 for up passengers only and 20 for down travel. These cars run empty in the opposite direction, yet careful and numerous readings fail to show any material difference in the results that are obtained.

Five basement traction machines showing 9.4 miles each per day, average 6.3 kw.-hr. per car-mile. Eight overhead one-to-one traction elevators with 16 landings, running express to the seventh floor, show 17.5 miles each per day and an average of 4.6 kw.-hr. per car-mile. Two overhead drum-type machines with light cars, stopping only at the first, seventh, eighth and ninth floors, travel 16 miles per day on a current consumption of 3.6 kw.-hr. per mile. Forty or more overhead drum-type machines averaging 14.5 miles per day, use 5.1 kw.-hr. per car-mile. The accuracy of all tests on individual machines has been demonstrated by comparing results obtained on two watt-hour meters and further checked by testing the machines in groups of five on a large watt-hour meter.

Carelessness Wrecks Gasoline Plant

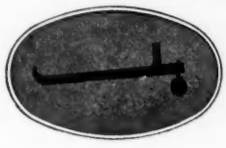
Carelessness on the part of a helper in the engine room of the Moon gasoline plant, near Tulsa, Okla., wrecked the building, as shown in the illustration. The explosion was due to two causes. First, one of the compressors exploded, filling the plant with gas; then

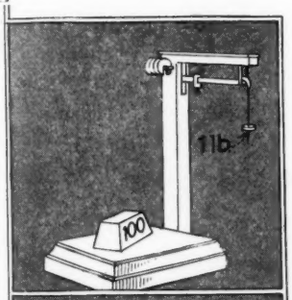
BUILDING WRECKED BY GAS EXPLOSION

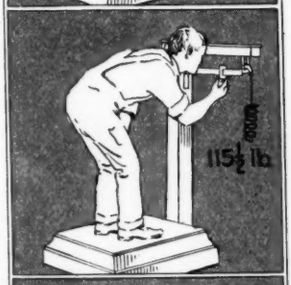
an inexperienced engineer's helper took it upon himself to stop the engine, and in doing so he made the mistake of pulling a spark-plug connection, which ignited the gas and caused an explosion. Eight men were seriously injured. As shown in illustration, the roof, which was made of corrugated iron, and the sides of the building were partly blown off.

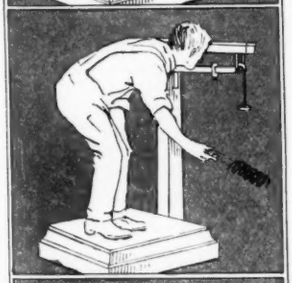
SMALL WEIGHTS ON BIG SCALES

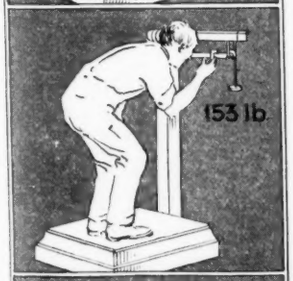
BY
M. D. Church

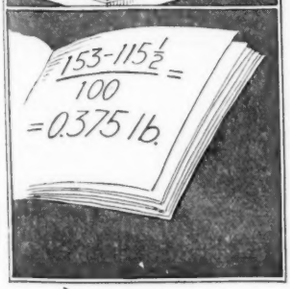












It is occasionally desired to weigh small articles accurately when the only means available is a platform scale designed for weighing hundreds of pounds. By a method outlined herewith, small articles may be weighed on platform scales within 1/100 lb. and often within 1/400 lb. of accuracy.

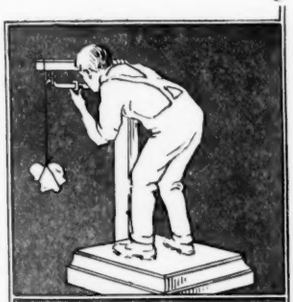
On most platform scales the 100-lb. weight actually weighs one pound. That is, one pound on the weight pan will balance 100 lb. on the platform. Other scales have ratios of 200:1 or 50:1. In any case the ratio can usually be found easily by reading the marks on one of the weights or weighing one or more of them.

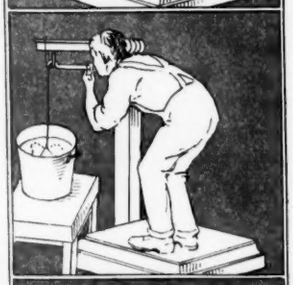
Let us assume we have a platform scale capable of weighing up to 600 lb. by half-pounds and that it has a ratio of 100:1. If it is desired to weigh a small article accurately, place it on the weight pan and run the sliding weight back to zero. Then put sufficient weight of any kind on the platform to raise the beam. Your own weight is usually most convenient. Balance the scales with the sliding weight, and note the reading. Suppose this to be 115½ lb., for example; then remove the article being weighed, say it is a spring, and again balance the scales by sliding the weight on the beam or adding scale weights to the weight pan. Note the reading again, say 153 lb. The weight of the article is $(153 - 115\frac{1}{2}) \div 100 = 0.375$ lb.

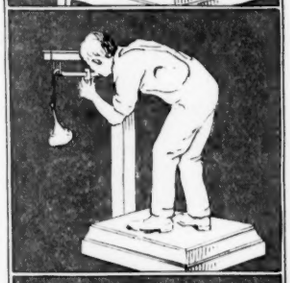
This method can be extended to cover many uses, as for any weight from as small as will tip the beam up to a weight as great as the range of the scale divided by the ratio.

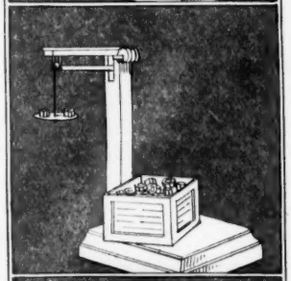
One particular use of this method is for the determination of specific gravity. If we have a specimen of metal, rock or other insoluble substance that will not float, the following method may be used: With a light cord hang the specimen a foot or so below the weight pan and take its weight. Then hold a pail of water so that the specimen is submerged and weigh again. Using the rule, specific gravity equals weight in air divided by loss of weight in water, if a piece of metal weighs 1.43 lb. in the air and 1.225 lb. in water, the specific gravity is $1.43 \div (1.43 - 1.225) = 6.97+$.

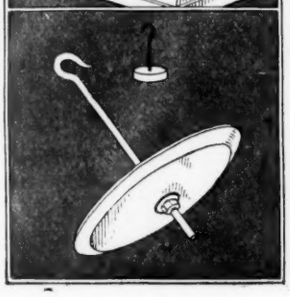
In the case of liquids hang an empty bottle on the scale pan by a cord and balance the scales. Then fill the bottle to a given point with water and find the weight of the water by the method already given. Then fill the bottle to exactly the same point with the liquid to be tested and get the weight of that. The specific gravity of the liquid will be equal to the weight of liquid divided by the weight of water. That is, if the water weighed 2.147 lb. and the weight of an equal volume











of a certain kind of oil was 2.042 lb., the specific gravity of the oil would be 2.042 ÷ 2.147 = 0.952.

The idea of using the ratio of the scales applies also to utilizing the scales for counting when the amount of counting to be done does not warrant a special scale. Suppose we have a thousand or so nuts to be counted. Place a box on the scale platform and balance the scales by the sliding weight. Then put the nuts into the box. Again balance the scales by piling nuts on the weight pan. If the ratio of the scales is 100: 1, there will be as many hundreds of nuts in the box as there are nuts on the pan. If accuracy is desired, the final balancing may be done by taking a few nuts out of the box and counting the odd nuts and those on the pan by hand.

When there is much counting to be done, it will be found handy to make a special pan out of a small pie tin and a piece of rod to take the place of the regular pan. It should be made to weigh exactly the same as the regular pan and will hold many more small parts. Such an arrangement will be found handy in any storeroom and will usually pave the way for a regular counting scale.

Industrial Plant Furnishes Street Railway Power

It is often possible for an industrial power plant to find some use for its excess power which will extend the period of the peak load without increasing its magnitude and at the same time materially benefit the new power user. An interesting example of this is the supply of direct current by the Westinghouse Electric and Manufacturing Co. to the Pittsburgh Railways Co. for the operation of its cars in and about East Pittsburgh, Penn. Owing to the tremendous increase in the number of employees at the Westinghouse plant, the present overhead equipment of the street railway was overtaxed for about two hours morning and evening.

To take care of this condition, connections were made between the railway-feeder system and the Westinghouse company's rotary converters in its power house. Since this arrangement has been in operation there has always been plenty of power to move cars at any time and the day's demand upon the industrial power plant has not increased, although its duration has been somewhat lengthened.

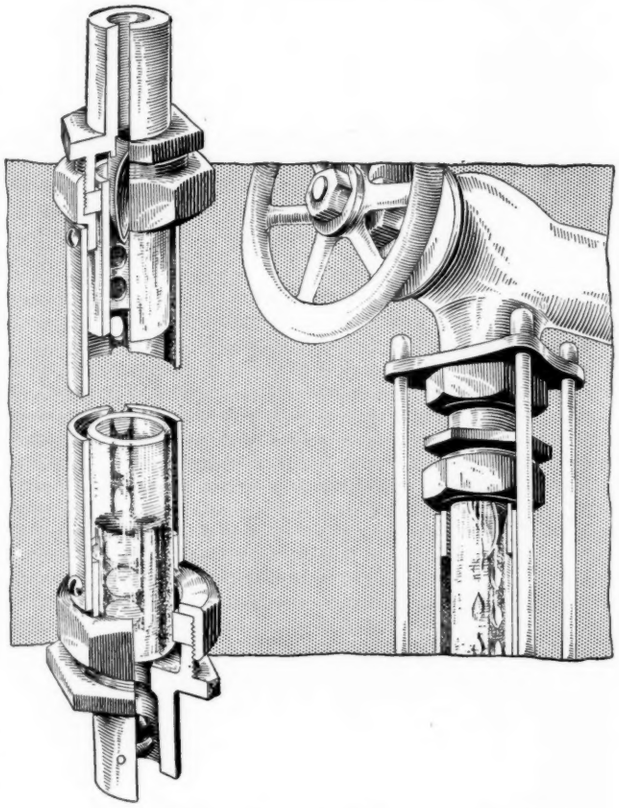
There is no doubt that many industrial companies similarly located with respect to transit lines extending out a considerable distance beyond the railway's last substation could use such a method with great advantage. While the revenue from the sale of power is of course desirable, the principal benefit will be found to be in getting employees to and from work on time, in which an ample supply of power is an important factor.

Ernst Safety Gage-Glass

One of the annoyances of the boiler room is the breaking of water-gage glasses. This is due to several reasons, such as the connections being out of alignment, erosion of the glasses at the upper end, due to the action of steam, cold drafts striking the glass, accidental breakage, etc.

These causes of breakage seem to have been overcome in the Ernst safety-gage glass, manufactured by Ernst & Co., Newark, N. J. The water glass is fitted into a centralizing member composed of an upper and a lower holder, each fitted with a packing nut. To a projection of each a removable metal half frame is secured, which holds the whole rigid. The back of the frame is drilled with ¼-in. holes and three lines of red are painted on the inside of the strip, which causes the water to show red when it is viewed from any direction.

In the upper connection there is a hollow pen-shaped member through which all condensation trickles without touching the glass, which is held tight in the upper and



DETAIL OF THE ERNST SAFETY GAGE-GLASS

lower members by rubber washers and packing nuts in the regular manner.

The top and bottom nipples of the centralizing device fit into the regular water-glass connection, the same as the ordinary water glass, but any ordinary packing can be used to keep them steam- and water-tight.

The bottom member of the centralizing device is fitted with a check ball which operates only when the glass breaks, in which case the ball is forced up against its seat, thus preventing the escape of water. As the ball operates in a vertical chamber, which, although containing a ball, has an area equal to that of the opening in the top member, it cannot remain in a closed position. Any glass will fit into the protecting frame, and the complete member takes the place of the ordinary water glass.

A country worth fighting for is a country worth saving for. Buy Thrift Stamps.

Editorials

The Miracle of the Mass

NORMALLY the mass of the people follow a few leaders. History is the record, page after page, of the doings of the nations under the guidance of a few men. But now and then in the record you come to a story—and it is always a thriller—in which the mass of the people yank their leaders from the head of the procession and move whenever and wherever their whims or their wisdom dictates. Such a page is being written now in the logbook of the world.

Mass movements are the miracles of the day. They are the big surprise. When the war began, our minds ran riot with the expectancy of inventions—of miracles of matter. We awaited the daring developments of wizardry—things wireless, things uncanny.

There have been miracles of matter, of course. In time of peace we would have acclaimed them as marvelous. But we give them a glance and turn with serious interest to the miracles of mass movement. If a chemist came forth now and turned gold into lead, our eyes would still be riveted to the Russian drama where diamonds have become dust, and dust is becoming—what? We look at Germany and Austria. Will the miracles of the mass overcome their own miracles of matter and make ours unnecessary? In England, they tell us, an orderly miracle of the mass is taking place—and in France.

Who doesn't sense the upgathering sweep of it at home? And if your feeling is one akin to fear, is there or isn't there, mingled with it and dominating it, a sense of relief because many of the hampering grips of the old order are passing into history?

It will be an interesting story when it is written by a future Carlyle; and those of us living in the life of it will understand it better when we read it than we do now. Old phrases will come back to us. "Cost Plus" will be one of them. We shall wonder then, not at the miracle of the mass, but at the stark madness of men—we had thought them big men—who played poker openly at a holy moment. The tragedy of it is that the poker players are a minority of what we have come to call our classes—distinctions by professions.

But the mass indignation does not discriminate. By its very nature it cannot discriminate. It is too overwhelming. It is a thing of the heart, not of the head.

The miracle of the mass can wreck us or save us. In all groups there are good and bad, in the moral sense. There are good lawyers and bad lawyers, good employers and bad employers, good engineers and bad engineers, good laborers and bad laborers. If the old classification by professions does not disappear—and that quickly—the outlook is ominous. If the employers stick together *as a class*, the lawyers *as a class*, the industrial workers *as a class*, regardless of the good and evil among them, Heaven help us. But if the upsweeping protest against the poker players of all classes destroys the class distinctions and aligns the good against the bad, then we are saved.

The hope of salvation grows day by day. Our fight against a ruthless autocracy to whom people are pawns has stirred our deepest age-old moral instincts. The sons of most of us are in that fight. Their lives cannot be gambled with by the poker players of any class, and this feeling is permeating the good men of all classes.

What the miracle of the mass will mean to us in this country lies in a large measure in the hands of the good employers. Are they courageous enough to meet their clear duty, to cut loose from an artificial class grouping, and align themselves, *by their acts*, with the good in the new moral grouping?

What will the future Carlyle say of them?

The Boston Turbine Accident

NATURALLY, much interest is centered in the accident to the thirty-five thousand kilowatt horizontal twenty-stage, impulse turbine in the O Street Station of the Boston Elevated Railway Co. The machine was of a type that represents the most advanced in design of single-cylinder turbines of large capacity. With condenser and air pump it represented an investment of about $335,000.

The details of the wreck are told on page 390 of this issue, so there is no need of reiteration here. It seems certain that deflection of the cast-iron diaphragm in the eighteenth stage causing the diaphragm to rub the wheel and release the buckets was the immediate cause of the accident, just as similar deflection of a cast-iron diaphragm in the same stage of this turbine once before stripped the buckets from the wheel.

Considering that the whole low-pressure end, rotor and casing, went to pieces, it is miraculously fortunate that no one was killed or injured.

As pointed out in the article, the question arises as to whether it is advisable to extend the use of steel to the large diaphrams in the lowest stages of these high-capacity machines. The question is one which cannot be finally answered offhand at this time. If in these very large diaphragms it is found that the cast iron is subject to frequent deflection; that the bond between the buckets and the disk and ring of the diaphragm soon weaken; or if these relatively thin disks are likely through any cause foreseen to be subjected to the stresses set up by centrifugal force imposed by accidentally revolving with the shaft—then steel seems advisable unless some means of avoiding these possible troubles with cast iron are found, and this seems possible. It should here be pointed out that the Boston accident is the only case we know of where a diaphragm let down on the shaft.

This Boston accident gives an impressive example to all operating engineers of the value of accurate, decisive and quick judgment while on duty and responsible for

turbines in their charge. With wheel speeds up to nearly one thousand feet per second, as in these large machines, the operator must be quick enough either in adjusting the thrust bearing or tripping the machine out of service to avoid longer than momentary rubbing of buckets and diaphragms at this speed. There must be no continued rubbing. That is a vital maxim. The operator must develop with the turbine. The builder and the employer must see to it that he so thoroughly understands how the machines under his care are put together that he can in effect look through the casing and see every detail, gage every clearance and anticipate the effect of this and that happening upon the safety and economy of the machine. The operator has the right to demand that every reasonable facility be available to him to know his machine. For this reason the policy of any builder to make it difficult to get drawings or photographs that would assist the operator in better knowing his machine is a policy that has no place in modern power-plant engineering, regardless of commercial considerations. All builders maintain corps of men for the very purpose of providing such information to operators. But that is not enough; the operator must get it and use it.

The accident at Boston is simply an unfortunate one in the development of the art. Because the turbine is the first of the particular type that it represents does not mean that there is anything fundamentally wrong in its design. We believe the design is safe. It is the opinion of all users of large-capacity machines whom we know personally that this design is safe. There are millions of kilowatts of such types of machines on order for large plants the country over. The accident at Boston is, perhaps, the most momentous in turbine history, and likely it will in time have done more good for turbine development than any other factor one can name.

What Is the Capacity of a Turbine?

IF YOU order a ten-, a twenty-, or a fifty-thousand kilowatt turbine and if, when installed, it carries a water-box load of just the capacity specified, but will not carry a thousand- or two-thousand kilowatt load swing above that amount without speed reduction and decrease in cycles—if these are the conditions, have you got a ten-, a twenty- or a fifty-thousand kilowatt machine? If the load was such as to swing one or two thousand kilowatts above ten, or twenty or fifty thousand, would you report the load to the public-service commission, if a public utility, as the average or as the peak maximum?

Of course these points have been quite thoroughly thrashed out, but all engineers do not agree. The disputes about machine capacity led to "max. rating," as engineers like to call it. That is, the greatest load a machine will carry with specified speed is the capacity of that machine. Technically, that seems reasonable. But the early conservatism of builders in rating their machines got engineers into the habit of expecting more than rating from them.

We thought that this question of rating had been settled, but there are still some wrinkles in it that have not been ironed out to the satisfaction of some folks. In fact, it is probable that recent events will open up the whole question anew, notwithstanding the set opinions of authoritative persons. Obviously, three factors influence the capacity of the machine; namely the pressure at the throttle, or better, the pressure at the first stage, the superheat and the vacuum. In disputes about the capacity of any particular turbine at some particular time—as, for example, on load swings—one naturally inquires what the steam and vacuum conditions were at the time. Were these below what the turbine required in order to develop the necessary capacity? If so, the cause is not in the turbine and the purchaser is at fault. If these conditions were normal, that is, as specified in the guarantee, and the swings, whatever they may be, five, six or seven per cent. of the turbine rating could not be carried, then is anyone at fault? Who is going to say where the limit is in this ability of a turbine to carry swings above the rated capacity? Who will say that the turbine should not be expected to carry any swing above its rated load? What is the consensus of opinion? One requisite is clear as concerns the purchaser—he should have a record of load, steam pressure at the throttle, superheat and vacuum as his evidence in event of dispute. Frank expressions now would clear the air, and *Power* welcomes such expressions.

Ash-Handling Apparatus

IN OUR issue of February 5 appeared an article by Herbert E. Birch entitled "Buying an Ash-Handling System." The editor who handled it did not know that the author was the consulting engineer of a manufacturer of conveyors of the bucket or skip type, and even if he had would not have considered that fact a disqualification. It is to specialists of this kind that we must turn for the latest and best information upon their respective subjects. We do not intentionally pay such authors for briefs of their cases in favor of their own apparatus nor permit them to go outside of engineering grounds in criticizing the apparatus of their competitors.

Letters from several manufacturers of apparatus of other types and their representatives express surprise that *Power* should have printed an article which attacks so viciously their type of apparatus. The "attack" was so well camouflaged as not to have been apparent to a disinterested editor, and its viciousness appears to be more evident to the minds of the victims of the supposed attack than to the less-interested reader.

The article stands simply for what it is, a presentment, by a man who is identified in a consulting capacity with one type of ash-conveying machinery, of some of the points to be considered in selecting an installation. It bears nobody's indorsement and is open to criticism, denial, refutation and reversal if anybody has a case against it and the will to state it. We have no interest or predilection in the matter and invite the fullest and freest discussion upon any statement which the author has made or any suggestion which he has advanced, not only from makers of the apparatus criticized, but from all our readers, especially those who have had experience with ash-handling apparatus of any kind.

Incidentally, we have an apparatus of one of the types criticized in our own plant.

Correspondence

The Conservation of Fuel

There have been some mighty good articles on fuel conservation published in various papers, but it seems to me that the good advice, in general, is directed at the operating engineers and boiler-room attendants. Without a doubt there could be enormous savings effected in some plants, but on the whole the best the operator can do is to operate the plant of which he has charge at the highest degree of economy possible under the given conditions. As a rule, the highest degree of economy cannot be brought about by the operator alone; some good sound judgment has to be exercised by the purchasing department as well. For instance, there are plants where at least 40 per cent. of the fuel burned goes for live-steam heating, yet such plants are operated condensing, with motor-driven auxiliaries and not enough steam-driven noncondensing units to even bring the temperature of the feed water up to 212 deg., to say nothing of heating buildings.

If the Government wishes to conserve the coal supply, it should request all municipalities and private corporations that contemplate building power plants or making changes, to submit full plans of the work and detailed information regarding it, to their engineering department for inspection. This would do away with the jumping-at-conclusions method and make the purchasing man sit up and take notice. LOUIS P. ALLEN.

Johnson City, N. Y.

A Talk to Firemen on Saving Coal

In the Jan. 22 issue of *Power*, there appeared an article on the conservation of coal which I am sure appeals to all who have any intimate contact with this, at present, scarce and costly commodity. That firing is an art learned only through experience is a fact that no engineer will deny; yet how small is the percentage of men who use their brains with their efforts when shoveling coal into furnaces.

Supervision of the coal pile by chief engineers is something which the average fireman resents, and often leads to the frequent changes that are made in the fireroom.

Mr. Bromley states that employers need educating as well as employees. While this is true, it does not get at the real seat of the trouble. To analyze the situation it is necessary to go back to the inception of the plant, to the point where it was planned. In many cases I think it will be found that the boiler plant, as well as all other machinery, was laid out largely according to the views of an architect. Boilers, boiler settings, grates, etc., agreeing to some arbitrary standard were installed with little regard to conditions as they would apply after completion. The result is that after the engineering staff has been placed in charge it must make the best of it.

The hints given for the handling of the different kinds of fires I think are good. They are practical. From experience I have found that the dumping grate is far more desirable than either the stationary or shaking grate. It seems, too, that the hand-fired stokers now being offered have a good field.

As regards the excessive ash content of the hard coals now available, most any engineer will agree that Mr. Bromley's statement is correct. Under these conditions, then, conserving the coal supply is extremely difficult, and when one considers that the cost of coal is about 70 per cent. higher this winter and that more of it has to be burned to get the required results, it is almost beyond human effort to economize in any plant where care is always used to see that only the required amount of coal is used to economically carry the load.

I should like to see a discussion in *Power* as to the probable savings to be gained by changing grates and ashpit levels under boilers built 20 years ago where the heating surface is approximately 30 in. above the grate, to the heights of 60 or 72 in. as advocated in Mr. Bromley's article. It seems that the time is ripe for a discussion on the relative merits of what is gained by keeping the water in the boiler at a certain level under all conditions of load, also if it is preferable to return the water of condensation to a storage tank or to pipe it to a governor through which it will be pumped to the boiler after passing through a heater and meter. H. H. BURLEY.

Brooklyn, N. Y.

Climbing a Smoke-Stack

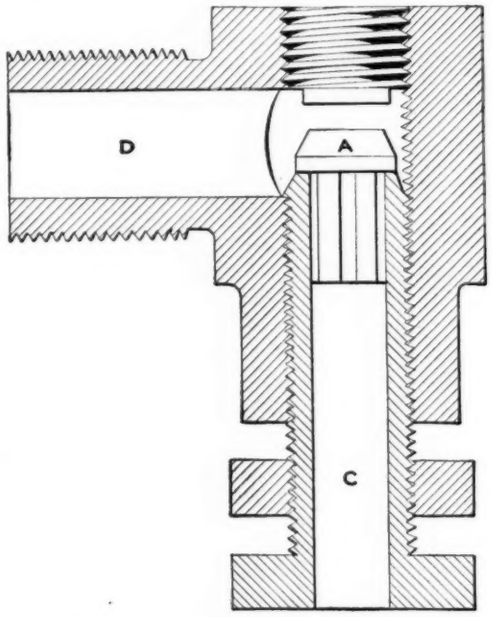
In connection with the letter by D. R. Hibbs in the issue of Jan. 1, page 24, regarding climbing smoke-stacks not fitted with ladders, the following may be of interest. A stack painter of my acquaintance uses three slings made of three-quarter inch rope with one end made into an eye; two of the slings have stirrups at the other end and the third has a long loose end. When climbing a stack, the slings are passed around the stack with the rope drawn through the eye, the feet being placed one in each stirrup, and the free end of the third sling drawn around the painter's waist and one end of a light hand line made fast to the waist line convenient to the painter's hand. In climbing the stack, the waist-line sling is placed around the stack above the stirrup lines and is raised by drawing it back and forth around the stack; the others are then raised the same way, one at a time.

When the painter reaches the top of the stack, he hauls up the paint bucket and brush with the hand line, hangs it on the waist line with a hook and paints the stack above the slings. Moving the slings around and down the stack, he paints the whole stack as he goes down. This man once painted a stack seven feet in diameter and one hundred feet high in eight hours from the time he started to climb up.

Ringwood Manor, N. J. A. A. BLANCHARD.

Improved Snifting Valve

Snifting valves are a rather despised and neglected pump accessory, but their utility is above question. Even slow-running boiler-feed pumps with a long stroke and a perceptible pause at each stroke have such valves



AUTOMATIC AIR INLET FOR PUMP SUCTION

fitted, although they are less necessary than on high-speed pumps, and there are many such, which must employ means to cushion the blow. They are usually fitted between the suction and delivery valves to admit air on the suction stroke, cushioning the blow of the plunger and seating the valves without shock; and there is a difference in running with and without them, especially under variable speed.

In the pulsometer type of pump the snifting valves are of more than ordinary importance, and unless they are correctly adjusted, the efficiency of the pump (never very great) is much impaired. The air has a special function in this type of pump in that it acts as a nonconducting layer between the steam and the water. Air being a bad heat conductor, heavier than steam and lighter than water, admirably fills the necessary conditions. The quantity of water delivered is seriously affected by imperfect adjustment of the snifting valves.

The usual fitting is in most cases leaky, the seat and valve get battered so that at each delivery stroke it leaks water, to the annoyance of the engineer, for the type of fitting usually employed is of a cheap character of soft brass, wears rapidly and is tolerated as a sort of necessary evil. Its function is to admit air and close against the escape of water, and while it does the former whatever condition it may be in, it often fails to perform the latter office. Retruing the seat is difficult, the fitting being of small size, while the screw adjustment for lift becomes slack after short service.

The improved valve illustrated was designed by a marine engineer now in charge of a shop making high-grade pumps, and it has had several years' trial with entire satisfaction. The chief feature of the design is a means of adjustment which controls the valve lift. The body of the valve consists of a hard-brass casting *D* fitted with an adjustable valve seat *C* held in the desired position by the locknut shown and a valve *A* made of hard bronze.

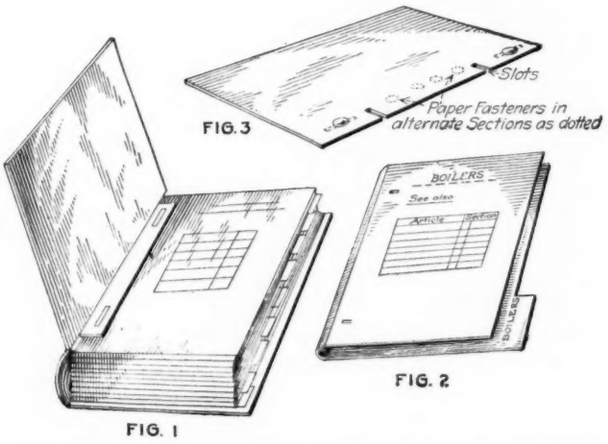
It will be seen that the machining is easy as one hole is drilled through the body and tapped out and the other, at right angles, breaks into the first. The adjustment for valve lift is by means of the portion of *C*, which may be screwed up so valve *A* is close to the stop or as far down as desired. Retruing the valve seat is done in a few minutes wherever that becomes necessary by the withdrawal of *C*. There is nothing to go wrong; it is a rational design for which credit is due to its originator, for although an inversion of ordinary practice, it needs only to be seen to be appreciated.

A. L. HAAS.

London, England.

Binder for Detached Pages

Readers of *Power* may be interested in the following description of a binder for keeping articles from periodicals in a handy form for reference. A standard *Power* binder is used with manila folders cut and folded as shown (Fig. 2) for each section subject and held in place by the binder strips. Pages from periodicals are clipped together for each section with standard paper fasteners, the edges trimmed and slots cut in the inner edge to pass the binder strips. These are then inserted in their respective folders and the whole binding tightened up in the usual way. The paper fasteners securing the articles in each section should be "staggered," in order to even up the thickness of



FIGS. 1 TO 3. LOOSE-LEAF BINDER FOR MAGAZINE PAGES
Fig. 1—The units all assembled. Fig. 2—One of the manila folders. Fig. 3—Pages clipped together ready to file.

the binding. To insert new articles, any section can be readily removed from its folder without disturbing those on either side.

When there are articles relating to different subjects, overlapping or on the same page, the pages are filed under one section or title and reference is made to the other article on the front of its particular section folder in a ruled space for that purpose. I have found it most convenient to have about fourteen section folders in each binder with the marginal title tabs $1\frac{3}{4}$ in. long in two courses making seven in the length of the folder.

Typical section titles are "Boiler Construction," "Scale and Corrosion," "Boiler Setting," etc., and the number of pages in any section, extending over a period of five years, varies between ten and forty, so that it is easy to refer to the particular information required; and as long as there is room, any article that has any item of interest is inserted and the items marked. Such an adjustable post binder, of a size to take standard pages, and fitted with manila folders ruled and cut for marginal title tabs and having suitable detachable clips for holding the articles in each section and securing them to the binder, would, in my opinion, be of great value to engineers who wish to keep only one or two articles out of any periodical. Couldn't someone get out a binder designed along these lines?

Montreal, Que., Canada. F. A. COMBE.

Helping Out a Worn Compressor

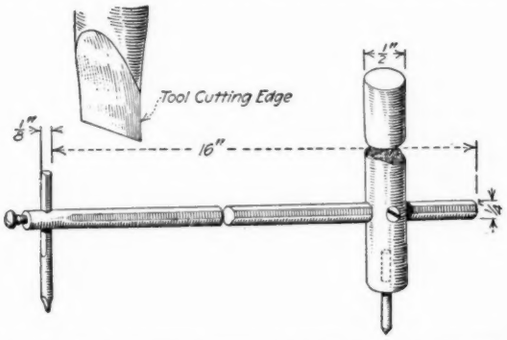
On taking charge of this plant I found the compressor supplying air to the Diesel engines so badly worn both in the valves and piston-packing rings that it was impossible to keep up the required pressure of 75 atmospheres. It was also impossible to get repairs within a reasonable time, therefore it was necessary to do something to overcome the trouble temporarily. The compressor seemed to be blowing back almost half of the air that was drawn in at the suction stroke so I connected a swing-check valve on the air intake and it worked "beautifully"; in a few minutes the air pressure increased from 45 to 80 atmospheres. That gives us a surplus, and we get rid of it by turning the check valve part way over so that it stays open late, allowing some air to escape.

The compressors are of an old two-stage, single-acting type and it is not likely that there are many of this type in service, but the idea may help someone get by while it is so hard to get repairs promptly.

Austin, Texas. F. C. WILLIAMS.

Cutter for Round Gaskets

The illustration shows a simple and easily made device for cutting round gaskets rapidly and accurately of any size within its capacity, from sheet packing. The saving in time is most pronounced when a number of gaskets of the same size are wanted, and it is



ADJUSTABLE CUTTER FOR GASKETS AND WASHERS

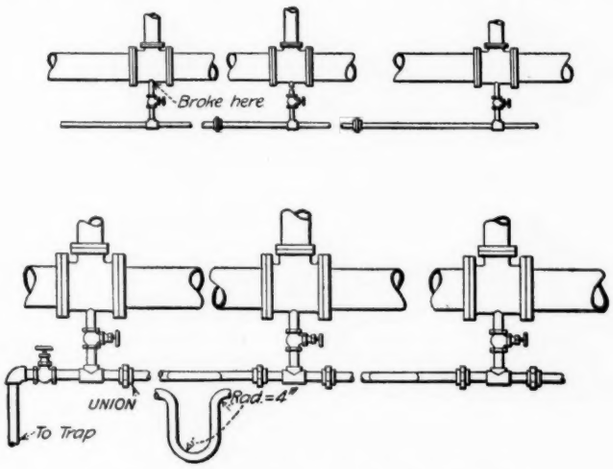
only necessary to set the cutter once for the diameter desired. It is constructed along the same lines as a beam compass. The main bar, or beam, made from ¼-in. cold-rolled steel rod, is ground flat on one side on an emery wheel to give a good bearing for the setscrew.

The center point in the handle is made from a broken twist drill of small diameter ground to a needle point. For the cutter use is made of another broken drill about ⅛ in. diameter flattened slightly on an emery wheel, as in the case of the main bar, to give the binding screw a good grip. The cutting end is ground V-shaped and sharp and given a fine edge on an oilstone.

Readville, Mass. H. M. NICHOLS.

How Not To Connect Drain Pipes

The drain line of a header was attached rigidly, as shown in the upper part of the illustration, and there was no chance for expansion, so it broke one of the nip-



OLD AND NEW HEADER DRAIN LINE

ples off one day and shut the plant down, proving that it was not designed rightly. I had some bends made and put in, after which there were no more leaks as there was plenty of chance for expansion; besides, whenever it was necessary to put a new gasket in any part of the header, the flanges could be spread without disconnecting the drain line.

Northport, Wash. N. C. GLEASON.

Taper for Flash Test of Oil

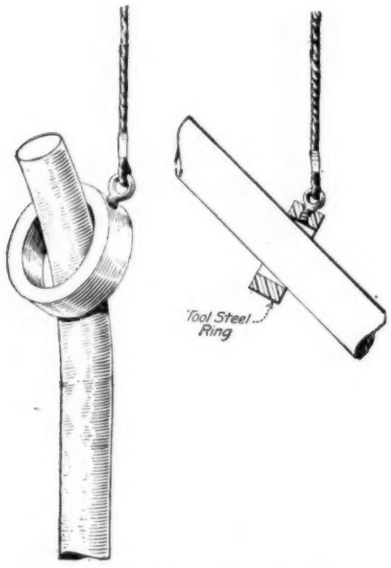
In applying the open-cup oil test for determining the flash and burning points of lubricating oils, a "lighted taper" is passed over the cup about a quarter of an inch above the surface of the oil, but a lighted string or broom straw, as usually suggested, is unsatisfactory to manipulate because embers may drop into the oil and spoil the accuracy of the determination of the flash point at least.

I have found that an old bunsen burner or chemical blowpipe connected to the gas supply with rubber tubing will give a fine gas jet which can be easily regulated to obtain the desired test flame. The blowpipe should be held so that the flame is in a horizontal plane. A cruder but effective "taper" can be made by inserting into the end of the gas tubing a piece of small tubular porcelain such as is used to support crucibles above bunsen burners. WILLIAM J. DANA.

Baltimore, Md.

Ring for Hoisting Wire

The steel ring shown is a time saver and gives a perfect grip when hoisting wires up to elevated lines inside or outdoors, where the common knot frequently slips. This ring can be used to raise any wire that is stiff



HOISTING RING FOR CABLES

enough not to be bent by the strain of the ring; the heavier the wire the more positive the grip. The ring is made of tool steel, with sharp edges and hardened.

Ozone Park, L. I. M. P. BERTRANDE.

Valve Opening Against Pressure

The damage and delay that can be caused by incompetent men handling machinery was demonstrated the other day in a plant where several elevator pumps take their suction supply at 80 lb. pressure from an elevated tank.

A helper, when ordered to start one of these pumps, found that the globe valve on the suction line was hard to open (on account of the pressure), but proceeded to apply force to it until the stem was broken, instead of first equalizing the pressure on the two sides by means of the bypass as he should have done. The pump was out of service for several days, and considerable expense was occasioned by this lack of knowledge on the part of the operator. W. T. OSBORN.

Newark, N. J.

Resistivity of Copper

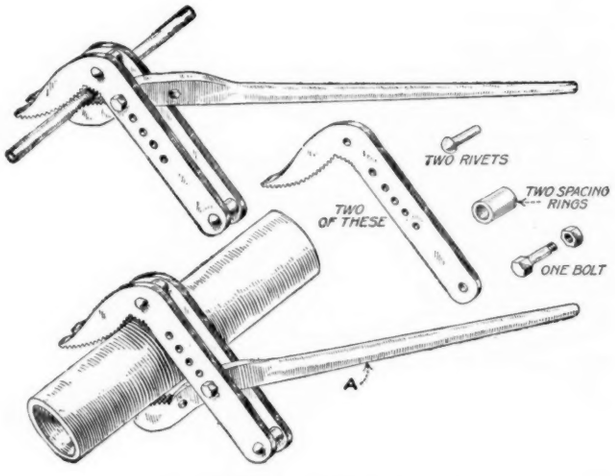
Certain formulas that are used for figuring the size of wire to transmit a certain current a given distance with a specified voltage drop read: Circ.mils = 10.6 $\times$ 2 $\times$ D $\times$ I $\div$ E_d. Others read: Circ.mils = 11 $\times$ 2 $\times$ D $\times$ I $\div$ E_d, where D equals the length of the circuit one way in feet, I the current and E_d the volts drop in the circuit. Note that the formulas are the same except that the constant 10.6 is used in one and 11 in the other. Why these two different values are used may be explained thus: The values 10.6 and 11 respectively represent the resistance per circular-mil-foot of copper. The resistance of copper or any metal increases with its temperature and varies with the purity of the metal; hence a circular-mil-foot of copper will have a resistance of exactly 10.6 ohms only at some certain temperature and when the metal is of a certain degree of purity. For example, copper of 98 per cent. conductivity has, at 68 deg. F., a resistance of almost exactly 10.6 ohms per circular-mil-foot. At a temperature of 86 deg. F., copper of 98 per cent. conductivity has a resistance of 11 ohms per circular-mil-foot.

It is evident, then, that the value 10.6 may be entirely correct for a certain condition and the value 11 ohms also correct for another condition. However, in making wiring calculations there are so many indeterminate factors that affect the problem that it is a waste of time to endeavor to attain great accuracy. The value D (distance) in the foregoing formulas can ordinarily not be determined within 10 per cent. and the value I (amperes) is usually also an approximation. For these reasons it is believed that, on the whole, the result will be as accurate if the value 11 is used instead of 10.6. Furthermore, the value 11 is easier to remember and can be handled with less labor. T. H. NASH.

St. Louis, Mo.

Pipe Wrench for Many Sizes

Having the bar *A* originally belonging to a large pipe wrench "kicking around" the power house, I decided to utilize it and avoid the expense of buying a new one. The upper jaws are home-made. They are different from the regular ones and in my opinion are better for



ADJUSTABLE PIPE WRENCH

some work and have a larger capacity or adjustment for different pipe sizes. The holes are for adjusting for various sizes of pipes. The two parts of the jaw are held together by two rivets with two spacing rings to keep the jaws the right distance apart. The construction is easily understood. J. A. LUCAS.

Ozone Park, L. I.

When you save and buy War-Saving Stamps, you help to make the world safe for democracy and at the same time make your financial future safe for yourself.

Inquiries of General Interest

Limitation of Size of Safety Valves—Why are not spring-loaded safety valves made larger than 4½ in.? M. F.

When safety valves are larger than 4½ in., unequal expansion of the parts from temperatures imparted by the steam is likely to cause leakage or derangement.

Dead-Weighted Safety Valve—What is a dead-weighted safety valve and what advantage has it over a weighted-lever safety valve? E. W.

A dead-weighted safety valve is one that is held to its seat by the dead weight of the valve and generally an additional weight, consisting of a cast-iron ball mounted centrally on the valve spindle. The principal advantage of this form of valve over a lever safety valve is that it cannot be so easily overloaded.

Auxiliary Valve on Single Steam Pump—Why is it necessary to provide an auxiliary steam valve on a single-cylinder steam pump? J. R. S.

Proper movement of the main valve cannot be derived from a positive connection to the piston rod, as the steam port would be closed gradually toward the end of the stroke, and although the stroke might be completed, there would be no movement of the valve appropriate for reversal of the stroke. Hence the necessity of an auxiliary valve to effect movement of the main valve.

Rotary Converter Hunting—What are the causes of a rotary converter hunting and how are they remedied? W. E. A.

The causes of a rotary converter hunting may be divided into two classes, mechanical and electrical. Mechanical causes may be present when reciprocating engines are used to drive the generators, due to the turning effort exerted on the crankpin not being uniform at all parts of the stroke, causing momentary variations in the engine's speed during each revolution. The momentary variations in engine speed cause variations in voltage and frequency of the generator which are transmitted to the converter and cause the machine to hunt. This cause may be remedied by using a heavier flywheel on the engine, or a governor that will not respond to these momentary variations. This trouble can also be alleviated by placing a damping winding, similar to the copper structure on the rotor of a squirrel-cage motor, in the pole faces. The electrical causes are excess drop in voltage due to the transmission line being overloaded, and also to the lack of dampers in the pole faces of the converter; the remedy in this case is obvious.

Hot-Water Supply in Conjunction with Hot-Water Heating—What are the objections, if any, of obtaining a hot-water supply out of the boiler of a gravity hot-water heating system? G. H. J.

For heating purposes the temperature of the water would need to be adapted to the variable requirements of the heating apparatus and thereby may be unsuitable for the hot-water supply. Another objection is that drafts of water thus made from the heating system would need to be replenished by a supply of cold water that would impair the operation of the heating system, and the sudden changes of temperature would have a tendency to warp and crack the boiler. If it is desired to dispense with a separate fire for obtaining a hot-water supply, it is better to heat the water by means of a water-back or pipe coil placed in the firebox of the heating boiler. Although this may reduce the size of the boiler firebox and interfere to some extent with the capacity of the heating apparatus and economy of fuel, these objections may be compensated by greater convenience and economy in operation of a single fire for the heating apparatus and a hot-water supply.

Requirements and Appointments of Fire Pumps—What are the leading differences between fire pumps and standard pumps? W. F. C.

Fire pumps are designed with special consideration as to reliability and durability. The valve area must be larger than that of standard pumps, as the demand for water may at any time be in excess of the rating, and the pump can then be run at a very high speed even if the operation may be regarded as unsatisfactory in an ordinary pump. A fire pump should be strong, rustproof and reliable and one that any inexperienced man, who may be excited and in a hurry, could start up instantly without doing any damage and should be provided with cushioning sufficient to prevent damage from pounding when the pump discharges against only atmospheric pressure, as from sudden breaking of a hose or discharge connection near the pump.

Closing Cracks in Brick Settings—What is the best material for pointing the cracks in brickwork of boiler settings? J. W. R.

Cracks develop from expansion and contraction, and once a crack forms, it will open wider from continued use of the boiler, as small pieces of the wall material fall into the opening with each contraction and, when reëxpansion occurs, these particles and the jagged fracture prevent the joint from closing as tight as it was at the time of the previous expansion. Hence for keeping a crack closed it is necessary to close the opening with an elastic material or cover the crack with a material that will adapt itself to increase of its width. A good plan is to fill the opening with dry asbestos cement, point the outside with ordinary lime mortar for holding the asbestos cement in place, and if serious objection is believed to result from renewal of the cracks, the leakage can be stopped by covering the openings with strips of muslin pasted on the outside of the wall with a good flour paste. The muslin strips should be thoroughly sized with the paste on both sides and applied when the openings are widest, which for most cracks will be when the walls are cold.

Required Size of Duplex Boiler-Feed Pump—What size of duplex boiler-feed pump would be suitable for boilers rated at 450 hp.? N. H.

To meet emergencies boilers are likely to be forced to deliver one-third more than their rated capacities, and in case of low water at such times, the delivery capacity of the feed pump should be at least double the rate of evaporation. To meet these conditions, without operating the pump beyond the speed proper for a pump in regular service, the regular service capacity needs to be about three times the steady requirement of the boilers when operated at their rated capacity. Allowing the rating to be equivalent to an evaporation of 30 lb. of water per boiler horsepower per hour, the feed pump should be of size suitable for a delivery in regular service at the rate of $450 \times 30 \times 3 = 40{,}500$ lb. of water per hour, or make a displacement equivalent to $40{,}500 \div (60 \times 8.33) = 81$ gal. $= 81 \times 231$ or 18,711 cu.in. per min. Allowing 6 in. stroke, and for maximum rate of delivery a piston speed of 65 ft. = 780 in. per min. (which will be the piston speed for each side of the pump), the pump would make $780 \div (2 \times 6) = 65$ revolutions, or $65 \times 4 = 260$ single strokes per minute; and neglecting the reduction of plunger area due to piston rods, each plunger area would need to be $18{,}711 \div (2 \times 780) = 11.99$ sq.in., which corresponds to about 3⅞ in. diameter. The usual commercial size of duplex pump coming nearest to the above would be $6 \times 4 \times 6$ in.; that is, 6-in. diameter steam cylinders, 4-in. diameter water cylinders and 6-in. stroke.

Economy of Refrigerating Power Plants*

BY VICTOR J. AZBE

Résumé of the various factors entering into economy of a refrigerating or ice-making plant. The boiler room, prime mover, auxiliaries and condenser and suction pressures are considered.

WHILE power plants are generally wasteful, the average refrigerating plant is especially so, by reason of the many factors that enter into the ultimate economy. It is generally accepted that five to six tons of ice is produced per ton of coal, but more often only one to two tons is obtained, and to find an ice plant where a saving as great as 50 per cent. could be made is quite common. Some of this loss is due to the improper equipment and improperly proportioned plants, but most of it is due to the fact that good refrigerating power-plant engineers are scarce.

Table I shows what a good operating engineer in a plant can do over a mediocre man. It is evident that the chief problem of the mechanical and refrigerating engineer is to develop the proper caliber of power-plant operator. A large percentage of the total loss is ordinarily found in the boiler room, due to either improperly selecting or burning the fuel. Close attention to CO_2 is necessary and seldom exercised. Proper installation of boilers and such damper arrangement that regulation at all loads can be maintained, are important factors.

TABLE I. RESULTS OBTAINED BY TWO ENGINEERS IN THE SAME PLANT WITH THE SAME EQUIPMENT

Tons of Ice per Ton of 10,000 B.T.U. Fuel

	1916	1917	Improvement, 1917 Per Cent.
March	2.88	5.08	76.7
April	3.64	5.02	37.7
May	3.74	5.12	36.7
June	4.00	5.44	36.0
July	4.16	5.53	32.9
August	4.32	5.48	26.7
September	4.06	5.21	28.3
October	3.96	5.35	35.1

Simple steam-driven ice plant. Distilled water can ice. In addition storage to the extent of 150,000 cu.ft. was maintained with average atmospheric temperature of 90 deg. F., for which no correction was made.

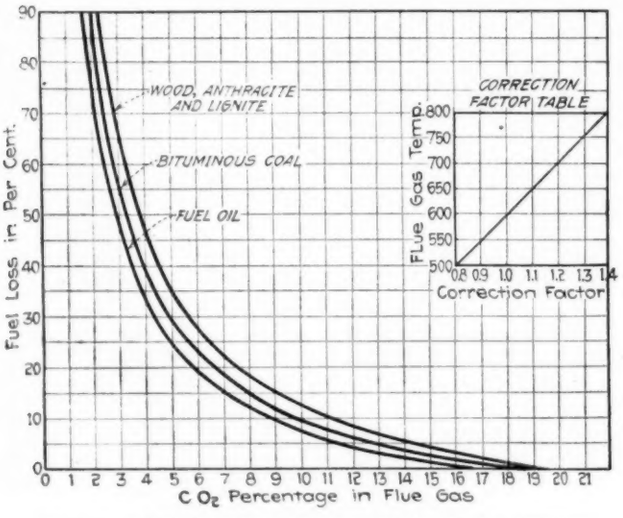


FIG. 1. LOSS OF FUEL DUE TO EXCESS AIR WITH VARIOUS CO_2 PERCENTAGES

Fig. 1 gives the loss of fuel with different percentages of CO_2 in the flue gases. Table II gives the loss due to carbon monoxide. It must be remembered that CO is not the only loss when there are smoke and incomplete combustion. There may be other gases escaping, having an equally great or greater content of latent heat that becomes unavailable.

In the boiler room close attention must be paid to baffling, gas velocity and cleanliness of heating surface, both internally and externally. These factors have an important bearing on flue-gas temperature, which is all-important when it comes to boiler efficiency.

Average relative values of various fuels are given in Table III. Wood and lignite have been somewhat discredited by being burned under improper conditions and by men unfamiliar with their peculiarities. At present many a plant in this country now burning oil or coal could change with profit to lignite or wood fuel. The data given in the table are conservative and should be obtained in any plant properly equipped and operated.

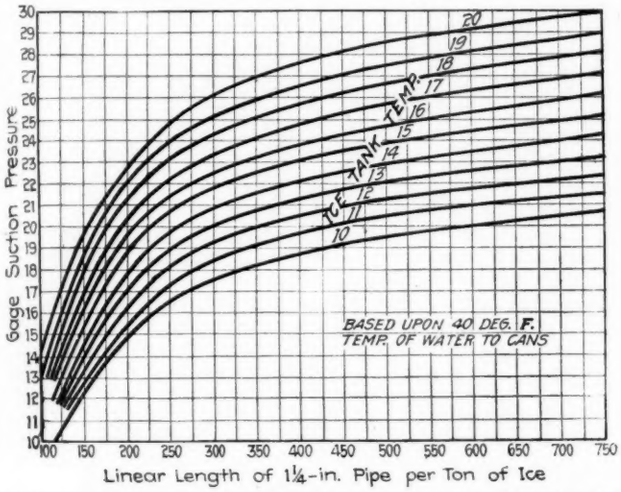


FIG. 2. RELATION OF LENGTH OF PIPE PER TON OF ICE TO SUCTION PRESSURE

Few plants operate on a discharge pressure as low as it should be. The condenser may be of improper design, improperly operated or filled with air. There may be insufficient water or poor water distribution, and the surface may be dirty. The condenser pressure should correspond to a temperature of 5 deg. F. above that of the cooling water leaving the condenser. The temperature of the ammonia liquid leaving the condenser should also be close to

TABLE II. FUEL LOSS DUE TO CARBON MONOXIDE IN FLUE GASES

CO_2		CO 0.25	0.50	0.75	1.00	1.25	1.50
5	B.t.u.	500	960	1,380	1,760	2,100	2,420
	%	3.5	6.6	915	11.1	14.3	16.6
6	B.t.u.	420	800	1,160	1,500	1,810	2,090
	%	2.8	5.4	7.9	10.2	12.3	13.6
7	B.t.u.	360	700	1,020	1,310	1,590	1,850
	%	2.4	4.7	6.9	8.9	10.8	12.5
8	B.t.u.	320	620	900	1,160	1,420	1,660
	%	2.2	4.2	6.1	7.9	9.7	11.3
9	B.t.u.	280	550	810	1,050	1,280	1,500
	%	1.9	3.7	5.5	7.2	8.7	10.3
10	B.t.u.	250	490	730	960	1,165	1,370
	%	1.7	3.3	5.0	6.6	7.9	9.3
11	B.t.u.	220	450	660	880	1,070	1,260
	%	1.5	3.1	4.5	6.0	7.3	8.6
12	B.t.u.	205	410	610	800	990	1,165
	%	1.3	2.8	4.1	5.4	6.1	7.9
13	B.t.u.	190	385	570	725	920	1,085
	%	1.3	2.6	3.9	4.9	6.3	7.4
14	B.t.u.	180	355	530	700	860	1,015
	%	1.2	2.4	3.6	4.7	5.8	6.9
15	B.t.u.	172	330	500	650	800	955
	%	1.1	2.2	3.3	4.4	5.4	6.5

*Abstract of paper read before the St. Louis Associated Engineering Societies.

the temperature of the coolest water and should pass to the evaporating coils through an insulated receiver and piping by some other way than a hot engine room. Where very cold water is available, a jacketed receiver is desirable. Flooded condensers, however desirable, are greatly misunderstood, and in some plants actually poorer results are obtained than could be expected with the ordinary atmospheric type.

Suction pressure is even more important than condenser pressure, but in spite of this far less understood. Few operating men will take advantage of higher suction pressures at lower loads. Plants actually can be found that in winter operate with suction pressures ten pounds lower than in summer. By increasing the suction pressure to correspond with the lower output, as much as 30 to 50 per cent. in power could at times be saved. Plants should be designed so that high-temperature work can be done at high pressures and in such a way that one or two low-temperature rooms will not spoil the economy of the whole plant. The importance of proper suction and condenser pressures may be realized when it is stated that every ten-pound reduction in ammonia condenser pressure represents about 5 per cent. saving, and every single pound increase in suction pressure represents 2½ per cent. saving. If the length

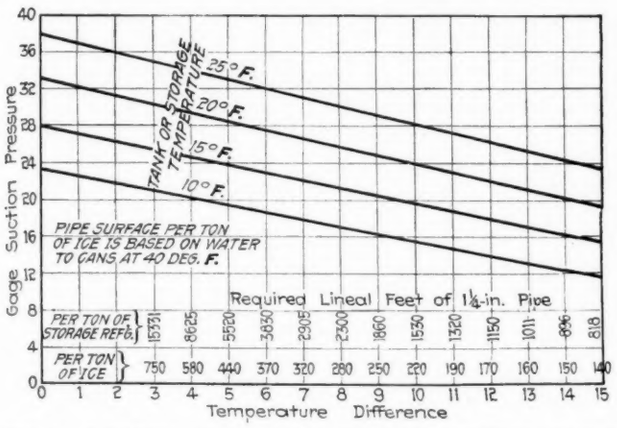

Gage Suction Pressure
TANK OR STORAGE TEMPERATURE
25° F.
20° F.
15° F.
10° F.
PIPE SURFACE PER TON OF ICE IS BASED ON WATER TO CANS AT 40 DEG. F.
Required Lineal Feet of 1¼-in. Pipe
PER TON OF STORAGE REFG.
15351 8625 5520 3850 2305 2300 1860 1530 1320 1150 1011 896 818
PER TON OF ICE
750 580 440 370 320 280 250 220 190 170 160 150 140
Temperature Difference

FIG. 3. LENGTH OF PIPE FOR VARIOUS TEMPERATURES TO OBTAIN CERTAIN SUCTION PRESSURES

of pipe in the tank is known, Fig. 2 will give the suction pressure to be expected; Fig. 3 is more complete as it also includes storage refrigeration.

It is known that the power required per ton of refrigeration increases rapidly as the suction pressure decreases. It is also known that the load on the engine decreases with

TABLE III. RELATIVE VALUES OF FUELS AND ICE PRODUCTION PER UNIT OF FUEL IN ECONOMICAL PLANTS

	Equiv. Evap. per Lb.	Equiv. Cost Not Considering Relative Labor Per Ton	Tons of Ice per Unit of Fuel Simple Non-Cond. Plant Tons per Ton	Tons of Ice per Unit of Fuel Comp. Cond. Plant Tons per Ton
Semi-bitum. coal	10.5	$4.50	8.2	14.0
Anthracite	9.7	4.16	7.6	13.0
Eastern bitum.	8.0	3.43	6.3	10.9
Western bitum.	7.0	3.00	5.5	9.5
Lignite	5.0	2.14	3.9	6.7
		Per 3,000 Lb. Cord	Tons per Cord	Tons per Cord
Wood, air dried	4.0	$2.57	4.7	8.1
		Per Barrel	Tons per Bbl.	Tons per Bbl.
Oil	13.5	$0.95	1.7	2.9
		Per 1,000 Cu.Ft.	Tons per 1,000 Cu.Ft.	Tons per 1,000 Cu.Ft.
Natural gas, 1,000 B.t.u.		$0.145	0.26	0.45

Expected production at about 15 lb. suction pressure and 185 lb. condenser pressure.

the suction pressure, which in turn tends to increase the steam consumption per horsepower developed. Thus low suction pressure not only increases the power per unit of refrigeration, but also decreases the economy of developing this power. The variation is shown in Fig. 4.

A serious loss in many plants is uneconomical auxiliaries. There are plants in which the auxiliary steam consumption is equal to or even greater than the steam consumption of the main units, and to further complicate the problem this factor is commonly accepted offhand as not at all serious.

As far as wastefulness is concerned, the duplex steam pump is the champion of them all. Its wastefulness becomes especially great when operated at a low rate of speed. The logical auxiliary unit is a properly designed centrifugal pump of variable speed and driven by power generated initially in an economical unit.

When designing a plant, a careful analysis must be made as to the number and size of auxiliaries. From the

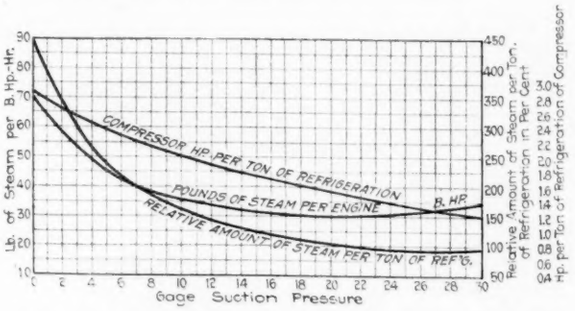

Lb. of Steam per B. Hp.-Hr.
COMPRESSOR HP. PER TON OF REFRIGERATION
POUNDS OF STEAM PER ENGINE
B. HP.
RELATIVE AMOUNT OF STEAM PER TON OF REFG.
Relative Amount of Steam per Ton of Refrigeration in Per Cent
Hp. per Ton of Refrigeration of Compressor
Gage Suction Pressure

FIG. 4 VARIATION OF ECONOMY WITH SUCTION PRESSURE, INCLUDING BOTH ENGINE AND COMPRESSOR

economic standpoint they might better be too small than too large. The former can be forced, while the over-large auxiliary is liable to excessive consumption of power or steam.

To state that the economy of a properly operated plant, as far as ice per unit of fuel is concerned, should be about the same at half load as at full load may be surprising, but Fig. 5 tends to prove the truth of this assertion and other such diagrams could be given. It will be noticed that the ice production varies from month to month, but the curve representing tons of ice per ton of 10,000 B.t.u. fuel is nearly flat.

Fig. 6 illustrates in a greater detail the foregoing contention. The curves, of course, apply only to a certain plant, and characteristics will vary with each plant. Still

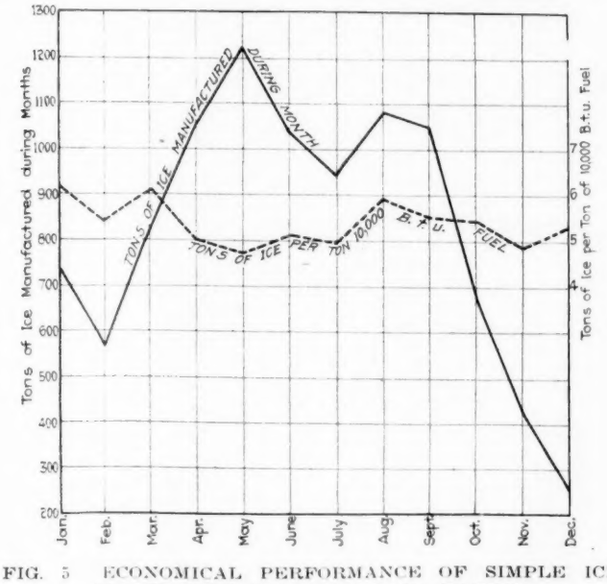

Tons of Ice Manufactured during Months
TONS OF ICE MANUFACTURED DURING MONTH
TONS OF ICE PER TON 10,000 B. T. U. FUEL
Tons of Ice per Ton of 10,000 B.t.u. Fuel
Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec.

FIG. 5 ECONOMICAL PERFORMANCE OF SIMPLE ICE PLANT WITH VARIABLE LOAD FACTOR

in a properly designed plant, and even in improperly designed ones, they will, or should, under proper operating conditions, follow the directions as given on this chart. It will be noticed that the ice-tank temperature increases as the load drops off, up to 20 deg. F., at which point it becomes flat. This curve is the base on which the efficiency of the system is built. The increase of the ice-tank tem-

perature is the factor that governs the increase of suction pressure on which the economy depends. All too frequently, it will be found that the ice-tank temperature maintained under low loads is the same or even lower than at periods of full ice production. A great many plants in winter will have half of their tank frozen down with ice. It

TABLE IV. RELATIVE EXPECTED EFFICIENCY OF VARIOUS ICE-PLANT INSTALLATIONS

	Rel. Eff. Per Cent.	Tons of Ice Per 20,000,000 B.t.u.	Increase of Heat Req. per B.Hp. at ½ Load Over Full Load	Ther. Eff.
Diesel engine	100	30	5.5	33.8
Gas-producer and engine	60	18	36	20.5
Locomobile	40	....	38	13.6
Turbine	36	....	7	12.2
Uniflow condensing engine	32	9.6	4	10.9
Corliss compound cond. engine	27	9.0	22	9.9
Uniflow non-condensing engine	21	6.3	8	7.0
Corliss compound non-condensing	20	6.0	21	6.8
Simple Corliss non-condensing	16	4.9	20	5.4
Simple engine non-condensing	14	....	17	4.8

Chart is calculated on a standard of 70 per cent. boiler and grate efficiency. An allowance of ½ hp. was made for refrigerating auxiliary load per ton of ice. A total of 3.5 b.hp. was taken per ton of ice, which corresponds to a back pressure of about 15 lb. suction and 185 lb. condenser pressure.

is known that large can surface per ton of ice is a factor of economy, but this can surface must be working, and not idle. The minute a block of ice becomes frozen solid, the can holding it ceases to do work, and if there are twenty cans per ton of ice in the tank and half of them contain solid frozen blocks, then, actually there are only ten cans per ton of ice, with the resulting necessary higher temperature difference to freeze the required amount of ice.

As soon as frozen, ice should be pulled, up to the point where the tank temperature gets to be 20 deg. F. Ordinarily, a higher tank temperature is not advisable owing to the danger that in case of a shutdown or breakdown, the tank temperature is liable to climb to the point where the ice in the can would begin to thaw and upon freezing damage the cans. The amount of frozen blocks in the tank is sufficiently important to warrant careful attention and should be made an item of daily report.

In the further study of Fig. 6 it will be noticed that as the suction pressure goes up the condenser pressure comes down. While the suction pressure is definite and can be calculated, condenser pressure in some plants and climates

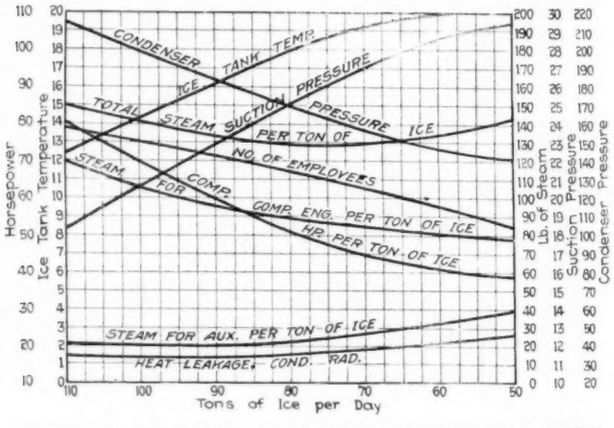


FIG. 6. GOOD ICE-PLANT PERFORMANCE, VARIABLE LOAD FACTOR

will go lower even than shown, or perhaps will tend to hold up, but it necessarily will always decrease a great deal with lower loads. With these two factors increasing or decreasing as shown, the compressor horsepower will decrease. This will reduce the amount of steam the prime mover requires per ton of ice, but owing to the fact that the economy of the engine decreases with the speed, the drop of the steam curve will not be as pronounced.

The steam required for auxiliaries per ton of ice decreases with the load. Heat leakage, condensation, radiation naturally remain constant. Adding the heat leakage, auxiliary steam and main engine steam gives the composite, or total, steam per ton of ice. This drops off, then increases, and at half load is practically the same as at full load. Consequently the fuel cost per ton of ice should be the same at half as it is at full load.

Table IV shows the relative efficiency of various prime movers for ice plants. The data here and also in other

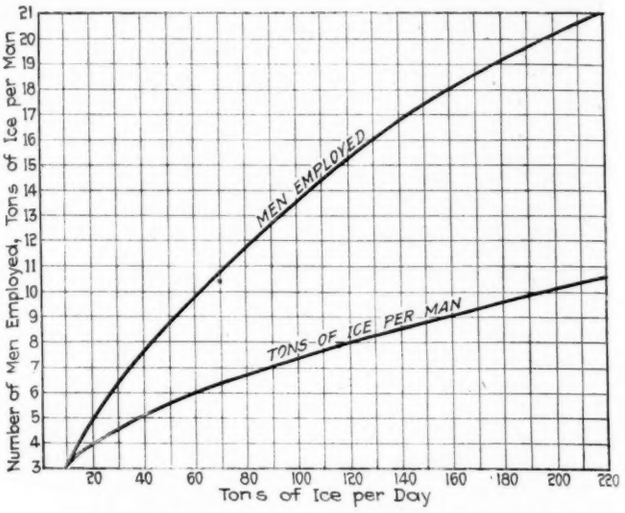


FIG. 7. LABOR IN STEAM-DRIVEN ICE PLANT

parts of the paper are based upon 20 million B.t.u., equal to a ton of 10,000 B.t.u. fuel. The general acceptance of this standard would make possible accurate comparison of plant operation. The data given in Table IV are conservative and should be attainable with reasonable operating ability. The column showing increased heat or power required at one-half load over full load is especially important in ice plants, where the load is so extremely variable.

Next to the fuel cost per ton of ice ranges the labor cost. Fig. 7 gives a good idea of what is to be expected in the average properly operated steam-driven ice plant.

The Plant Engineers' Club of Boston

The Plant Engineers' Club was planned in 1915 by Henry S. Dennison, of the Dennison Manufacturing Co., and E. D. Freeman, of the B. F. Sturtevant Co., along the lines of a similar organization which includes managers of plants and which is called the Factory Managers' Club. Mr. Dennison gave a dinner at the City Club on June 9 of that year, to which he invited about 25 mechanical engineers, master mechanics and chief engineers of various plants in the vicinity of Boston. As a result of this meeting the Plant Engineers' Club was organized. The meetings, which are held each month, usually are followed by an informal dinner, and occasionally a visit is made the same afternoon to one of the plants represented by the members of the organization.

Considerable time was spent during the first year in the study and preparation of a code for continuous boiler-room tests so that the members could adopt a standard by which they could bring up the over-all efficiency of their plants and compare them with what the other members are doing. They have found this code of great value, and it has a tendency to improve the general efficiency of the boiler plant, obtaining very much better results than they had been able to get formerly. The next meeting will be held at the Boston City Club, Mar. 20, at 6:30 p.m., and will be devoted to a discussion of the Cost of Coal Handling and the Storage of Coal. Mr. Eaton, of the Waltham Watch Co., will also recount his recent investigation on the use of powdered coal in large manufacturing plants.

The membership of the club is limited to superintendents, master mechanics and engineers of plants, not more than one in each line of business and not more than 25 in all. The officers are: G. L. Finch, president; H. C. Eaton, vice president; H. S. Scott, secretary-treasurer.

Lubrication of Air-Compressor Cylinders

Recent disastrous explosions in air-compressor systems present striking examples of the danger existing from the use of ordinary engine oil in the air cylinders of air compressors. Only a pure mineral oil, with a flash point as high as good lubricating qualities will permit, should be used. As little as possible of even the best oil should be used.

Numerous cylinder oils are compounded, and such oils are likely to produce a carbon that will stick the valves and collect on valve faces and other parts of the cylinder and valve chambers, resulting in a dangerous condition.

Air receivers are liable to explosion from accumulated oil deposits. Every receiver should be equipped with a pressure gage, a safety valve, and proper drains, and all reservoirs and likely places of deposit in the air line should be thoroughly and frequently drained and cleaned. It is bad practice to have the inlet of an air compressor take from a hot or dusty room—the air should be cool and as clean as possible.

The practice of throwing kerosene oil into the inlet of an air compressor to clean it is an extremely dangerous one, and the cause of an explosion under such circumstances is not difficult to understand. Lubrication of the air cylinder with soapsuds (preferably made of soft soap, about one part soap to fifteen parts water) for a few hours each week (or less frequently if the load is light), instead of oil, will help very materially in keeping the cylinder clean. The only danger from the use of soapsuds is rust, and this should be overcome by being careful to discard the soap and feed the cylinder with oil an hour or so before shutting down. The receiver blowoff should then be opened and the accumulation of oil and water drained off.

An air-compressor engine should not be controlled by the air pressure alone, as many are, but should be fitted with an auxiliary governor which will act as soon as the speed rises above a certain predetermined limit. This will prevent the engine from "racing" in case an accident to the tanks or piping causes a sudden lowering of the pressure. It is not necessary for an explosion to take place to produce a lowering of the pressure, as the giving way of a pipe, valve or tank from any cause will have the same effect.—*The National Safety Council.*

Engine-Room Rules

Employees should be strictly forbidden to enter the engine room except for a special mission, and then should remain only as long as necessary.

The engineer should not be permitted to leave the engine room until some other attendant who is thoroughly familiar with the engine, valves and signals is present to take charge.

No person other than those responsible for the operation of the engines should be allowed to touch any valves or other part of the mechanism or approach any moving part.

No one except the attendants should be permitted to go inside the railings or upon footways when the machinery is in motion.

The safe speed for each flywheel should be known, and in no case should this be exceeded. Flywheel revolutions should be recorded every day in order to make sure that the engine is not running over the speed limit.

All parts of engines and accessories should be frequently and thoroughly inspected, and daily tests should be made of the governor mechanism and automatic engine stops.

Under no circumstances should engines be started until they are thoroughly cleared by alternately blowing live steam through each end of the cylinders, and the steam pipe and cylinders thoroughly drained of all water. The drip should be left open until the load is put on and then closed. Be sure to warm the engine cylinder at both ends.

In shutting down, the drip valve should be left closed until the engine is stopped. If the throttle is equipped with a bypass valve, the throttle should be closed and engine stopped with the bypass. This gradually stops the engine, avoids the pumping effect of the piston and prevents water being drawn into the cylinder.

Never attempt to "bar" a flywheel around nor pull it off center by grasping the belt when the steam pressure is on.

Never start to take cylinder head off or piston out of cylinder without making sure that the throttle and exhaust valves are shut tight and locked and the drains wide open; nor without trying the indicator cocks to see whether there is any pressure on.

Never stop the air pump before stopping the engine (condensing), as the condenser and exhaust pipe may be flooded and overflow into the cylinder.

All steam traps should be kept clean and in working order. Should a trap get out of order, and it be impossible to repair it at once, the bypass should be opened sufficiently to pass off all water which might collect.

Leaks in pipes, flanges or gaskets should be repaired at the earliest possible time.

In opening up a cold line, all available drips should be opened. The line should be warmed by opening the bypass where possible or by opening the stop valve sufficiently to warm very slowly. Never open the main valve until certain that the line is thoroughly heated. An inexperienced attendant should not be allowed to turn steam into a cold line until properly instructed.

Automatic valves should be frequently examined to insure their proper action in emergency.

Under no circumstances should vacuum breakers, governors, engine stops or other safety devices be blocked or otherwise made ineffective. If such apparatus is out of order, it should be repaired at once.

Do not stand in front of cylinder head of engines.

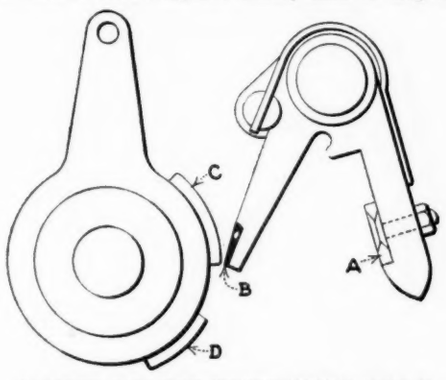
Do not place any material, tools, etc., on platforms or stairs around engine. They might fall off and injure someone below.

Never work in a gas-engine room alone; always have a helper with you.

If you find a man overcome with gas, get him into the open air at once, send for the doctor and notify the foreman.

Smoking and open lights should be forbidden around gas machinery and gas pipes; otherwise an explosion might occur.—*The National Safety Council.*

It occurs not infrequently that the steel toe *B* becomes worn down as shown in the illustration (reproduced from *Power and the Engineer* for Apr. 20, 1909). In order to get the desired trip after the toe *B* has worn down thus, attendants have been known to shorten the regulator rod so as to bring down the steel *C* nearer to *B*. This practice usually results in throwing the safety-cam or trip *D* out of



SAFETY CAM TOE EXCESSIVELY WORN

reach of the toe *B*. The danger attaching to such a condition is obvious. If the governor belt should break, away goes the engine with steam being admitted full stroke, unless perchance the engine is equipped with an independent safety stop or a "governor stop." The engineer should also make sure that he does not make the safety trip inoperative by rolling the eccentric ahead, in order to get compression at the end of the stroke.—*The National Safety Council.*

Daylight Saving Advocated by United States Chamber of Commerce

Fifty-two important reasons for the prompt passing of the daylight-saving bill were recently given Congress in the report of the Committee on Daylight Saving of the United States Chamber of Commerce. The items in relation to the immediate reduction in the use of light and heat, with the attendant saving of coal, are of the most interest to engineers and manufacturers.

More than 1,500,000 tons of coal a year is the estimated saving even if the measure is in effect only for the shortest period that has been suggested; and the saving in fuel oils is equally impressive. The savings would occur in both direct and indirect ways. The amount of coal that will be saved if the clock is moved ahead one hour would differ with the method in which daylight saving is used. Calculations computed for different periods based upon the actual British experience in the summer of 1916, and modified by allowances for differences in latitude give the following savings in coal for the United States:

1. Saving of 150 hours of a yearly average of 1320 per year requiring artificial illumination in the United States, that is, by daylight saving between second Sunday in April and last Sunday in September according to the Calder bill (S. 1854) now before the House Committee on Interstate and Foreign Commerce:

	Tons Coal
In electricity for lighting	660,000
In gas for lighting	144,000
	804,000

2. Saving of 190 hours from the yearly average; that is, with clocks moved ahead one hour between Apr. 1 and Nov. 30:

	Tons Coal
In electricity for lighting	836,000
In gas for lighting	183,000
	1,019,000

3. Saving of 198 hours from the yearly average; that is, with clocks advanced one hour throughout year:

	Tons Coal
In electricity for lighting	871,000
In gas for lighting	190,000
	1,061,000

The saving in coal used for these purposes could be represented approximately by the following percentages:

1. With saving of 150 hours: Amount of coal used for lighting through gas and electricity, approximately 15,750,000 tons; amount saved, 804,000 tons; percentage saved, 5.

2. With saving of 190 hours: Amount of coal used for lighting through gas and electricity, approximately 15,750,000 tons; amount saved, 1,019,000 tons; percentage saved, 6.5.

3. With saving of 198 hours: Amount of coal used for lighting through gas and electricity, approximately, 15,750,000 tons; amount saved, 1,061,000 tons; percentage, 6.6.

These figures do not include the saving that would be obtained at isolated plants and at electric-power plants which sell power for lighting. To be borne in mind, too, is the fact that the estimate has been made on a basis which assumes that the use of electric energy and gas for lighting is spread evenly over the country, whereas as a matter of fact 57 million electric lights out of a total of 76 million in the country are in the New England, Middle Atlantic and Northern Central States, where the advantages of daylight saving will be most striking.

The saving of coal through substitution of a morning hour of moderate illumination for an evening hour of maximum use of electricity and gas illustrates ways in which very important savings in coal would be obtained.

"Great Britain, France, Italy, Germany, and eight other nations have adopted daylight saving since the outbreak of the war," says A. Lincoln Filene, of Boston, chairman of the committee that prepared the report for the United States Chamber of Commerce, "and in all of them it is a great success. In England the saving in the use of artificial light and fuel is estimated at $2,500 000 for the summer months alone. In France the saving has been estimated to be 10 per cent. of the coal ordinarily consumed by the gas and electric undertakings. Adopted as a war measure, it has resulted in such increased efficiency and such marked economy that there is no question of a return to the old ways after the war."

Supporting the daylight-saving measure are the President of the United States; Herbert C. Hoover, the United States Food Administrator; Dr. Harry A. Garfield, the United States Fuel Administrator; E. N. Hurley, Chairman of the Shipping Board; the Council of National Defense, literally scores of state and municipal civic bodies and the more than one thousand chambers of commerce and commercial organizations comprising the membership of the Chamber of Commerce of the United States.

New Jersey Boiler Inspection Bureau

A boiler-inspection bureau for the State of New Jersey was provided by the legislature at its recent session by passage of Senate Bill No. 209, which has received the approval of Governor Walter E. Edge. The act goes into effect immediately. The bureau is established in the Department of Labor, consisting of the Commissioner of Labor, as head, and the members of the Steam Engine and Boiler Operators' License Bureau of the Department of Labor that was created under the provisions of the act approved Apr. 14, 1913, and amended by the act approved Mar. 29, 1917, together with such inspectors as the Commissioner of Labor shall deem necessary. The new bureau will be in charge of the inspection of all steam boilers located within the state carrying a pressure of more than 15 lb. per sq.in. Section 3 of the law provides:

Any person who shall be a citizen of the State of New Jersey, who has had at least five years' experience as an engineer in the care and operation of steam boilers, or who has had at least five years' experience as a boilermaker, or who has been for five years an inspector of an insurance company issuing insurance upon boilers and licensed to do business within this state, who shall satisfactorily pass the examination hereinafter provided for, shall be eligible to the office of inspector in the said Boiler Inspection Bureau.

The Commissioner of Labor is authorized to direct the members of the Steam Engine and Boiler Operators' License Bureau to hold examinations of inspectors, and he is to prescribe the rules and scope of the examinations, appoint the necessary inspectors from among the successful candidates and issue licenses to inspectors so appointed. When so licensed, inspectors are authorized and empowered to conduct inspections and examination. Inspectors shall hold office during the pleasure of the Commissioner of Labor and shall perform such duties as he may direct.

The act requires that all steam boilers within the state carrying a pressure of more than 15 lb. per sq.in. shall be inspected internally and externally and be subjected to a hydrostatic test, "if necessary," at least once in each year by an inspector of the bureau, excepting boilers that are inspected in accordance with the act by insurance companies, whose inspectors have been duly licensed by the Commissioner of Labor. The owner of any steam boiler who shall use or allow to be used a steam boiler in violation of any provision of the act shall be liable to a penalty of $50 to $100, to be collected by suit in the name of the Commissioner of Labor. Section 15 provides that all steam boilers shall conform to the regulations and standards adopted by the State Board of Boiler Rules.

Steam boilers in marine or railroad service that are subject to United States Government inspection and regulations and also fire-department apparatus and motor road vehicles are excepted.

A fee of $6 and traveling expenses of the inspector is to be paid by the owner of each boiler inspected and collected by the inspector, $1 of which is to be turned into the state treasury and $5 and expenses to be retained by the inspector as his compensation.

In addition to the annual internal and external inspection, each boiler is to be inspected externally as nearly as may be at the expiration of six months after the annual inspection. For such external inspection the owner of the boiler is to pay the inspector a fee of $2.50 in addition to the actual railroad fare.

Bituminous Coal To Be Mined Clean or Sold at Less Than Fixed Price

The United States Fuel Administration has announced the organization of an inspection system to enforce the mining of clean coal.

During last winter much of the output of bituminous coal reached the market containing a large percentage of slate and other impurities. The effect of this has been not only to reduce the heating value of the coal, but to put an additional unnecessary burden upon transportation facilities.

Under the inspection system, coal condemned by the Fuel Administration for lacking preparation or because it contains a high percentage of impurities will be sold at 50c. per ton less than the fixed Government price for the mine.

ORDER EFFECTIVE MONDAY, MAR. 11

The inspection system will be operated through the district representatives of the Fuel Administration in the various coal fields. The order became effective Monday, Mar. 11. It provides:

UNITED STATES FUEL ADMINISTRATION,
Washington, D. C., Mar. 7, 1918.

REGULATION CONCERNING CLEAN COAL

The United States Fuel Administrator, acting under authority of the Executive order of the President of the United States dated Aug. 23, 1917, appointing said administrator, and in furtherance of the purpose of said order and of the purposes of the act of Congress therein referred to and approved Aug. 10, 1917, hereby orders and directs that until further or other order, and subject to modification hereafter from time to time and at any time:

Section I: Authority is hereby given to the district representatives of the United States Fuel Administration to appoint a sufficient number of inspectors in their respective districts to carry out the terms and provisions of this order, and to assign to each of said inspectors a particular territory.

Section II: It shall be the duty of each of said inspectors:

1. To cover his territory at as frequent intervals as may be consistent with thorough inspection; the inspectors shall be qualified by knowledge and experience of the particular district or districts in which the inspection is to be performed, and shall familiarize themselves with the conditions under which the coal is produced and prepared, so as to enable them to effectually carry out the terms and provisions of this regulation, the intent being to reinstate the cleaning of coal at the working faces of the mines; to reinstate employment of slate pickers with a view of bringing the ash contents of coal back to approximately the standard of normal times. Furthermore, where the coal in any part of the mine is found to be naturally of such character as to be unfit for market, judging from the usual standard of the district, the district representative may order the mining suspended in said part or parts of a mine until or unless proper cleaning methods be adopted; provided, however, that the workings shall not be so suspended where the nature of the mining to be done is necessary to preserve the mine from damage, or where a cessation of work endangers life or may result in serious risk of flooding, of explosions, or of squeezing.

2. To report daily to the district representative of the Fuel Administration, mines inspected, the condition of the coal as loaded; methods being employed to prepare and clean the product; whether or not the product being shipped to market is, in his judgment, a well-prepared and merchantable product. All reports of inspections shall be made in quadruplicate, one to be forwarded by mail to the Fuel Administration, Department of Inspection, at Washington, D. C.; one to the district representative; one to the operator; and one to be retained by the inspector for his personal files.

Section III: Inspectors are authorized to condemn at the mines any coal loaded in railroad cars which, in their judgment, is not properly prepared; and any inspector finding unmerchantable coal shall immediately notify the district representative and the operator by wire or in person and in writing, giving the car numbers and initials of any and all cars so rejected and stating the facts on which such action was based. A copy of such notice shall be immediately mailed to the United States Fuel Administration, department of inspection, and to the district representative. If the district representative approves the inspection report, he shall so notify the operator at once; in which case, unless the operator unloads and reprepares the rejected coal, the consignee shall be permitted to deduct 50c. per ton from the authorized price for the grade of coal with which the car is loaded, provided, however, the consignee after examining the coal may at his option pay and the operator may receive the full authorized price. Each invoice covering the sale of condemned coal shall bear the following notation, "This reduced price is fixed by the United States Fuel Administration as a penalty for improper preparation." The operator shall thereupon immediately report to the United States Fuel Administration, department of inspection, at Washington, and to the district representative the disposition made by him of said car or cars of coal, and shall accompany his reports with a copy of the invoice.

The district representative, where repeated violation of this regulation has taken place, or in flagrant cases, shall require a special written report from the operator, which report shall be transmitted by said district representative to Washington with his conclusions thereon, all of which is subject to review by the United States Fuel Administrator.

This order or regulation shall not operate to change the terms, conditions, or validity of existing contracts, but new contracts shall be made subject to this order.

Above regulation to become effective Mar. 11, 1918.

H. A. GARFIELD,
United States Fuel Administrator.

Coke Breeze for Steam Raising

In a recent paper on low-grade fuels for power, before the Liverpool Engineering Society, Mr. Kershaw, as reported in the *Power User*, pointed out that coke breeze, as the fine coke is called which is washed from the quenching tables and grading screens in gas-works and byproduct coking plants, has lately come into prominence as a useful and cheap fuel for power generation. The ash content varies from 20 to 30 per cent. and the moisture from 10 to 20 per cent., so that it may be classed as low-grade, either on account of its contents of incombustible matter, or on account of its fine state of subdivision.

The conditions required for the successful combustion of coke breeze under steam boilers are now well understood, and there are many plants in operation in this country where it is being employed either alone or mixed with ordinary bituminous fuels for steam generation. When coke breeze or coke ash containing over 30 per cent. of incombustible matter is to be burned alone, some form of external furnace of the dutch-oven type becomes necessary for its complete combustion, and in this case the advantages offered by the internal fireboxes of the marine and Lancashire type of boiler are lost. Forced draft will still be necessary to burn the fuel, and the radiant heat from the furnace can be utilized by means of hollow walls for preheating the air before it is drawn into the furnace by the fan or steam jet—the heat of the gases can be best utilized in the water-tube type of boiler. Underfeed stokers are sometimes used with this furnace, but as the proportion of ash in the fuel rises, the difficulty of obtaining anything like complete combustion of the carbonaceous matter with mechanical stokers increases.

When burning a mixture of bituminous coal and breeze, it is very important that the fuel should be well mixed. A method of burning the mixed fuels on chain-grate stokers which is stated to have given good results is to fit an additional hopper to the front of the stoker, by means of which a layer of breeze is fed on to the chain-grate before the ordinary fuel comes down upon it from the hopper above. The grate then travels forward with two layers of fuel upon it, the coke below and the bituminous above, and the proportionate depth of these two layers can be varied by altering the relative speeds at which the two hoppers deliver their fuel onto the grate.

The idea that a technical paper is dry at best, and that the English employed in it is of small consequence has long been proved incorrect. There is so much nowadays that is well written that no busy professional man will spare the time to read and digest an ill-written paper.—*Harrington in the Sibley Journal.*

Merchant Marine Conference at Boston

Problems that are expected to result in greater efficiency in the manning and operation of American merchant ships, improvements that will be welcomed by the ship operators and crews alike, were discussed in a conference of representatives of leading maritime organizations and United States Shipping Board Recruiting Service officials at Boston, Tuesday, Mar. 5.

Henry Howard, director of the Shipping Board Recruiting Service, presided. Among those taking part were Edward F. Flynn, assistant to the director of recruiting; John H. Pruett, of New York, national president, American Association of Masters, Mates and Pilots; Andrew Furuseth, president, International Seamen's Union; H. P. Griffin, president, Marine Cooks' and Stewards' Association of the Atlantic and Gulf; Thomas L. Delahunty, of New York, business manager, Marine Engineers' Beneficial Association; John Olson, of the Marine Firemen, Oilers' and Watertenders' Union of the Atlantic and Gulf; Bert L. Todd, of New York, secretary, Ocean Association of Marine Engineers; Parker H. Kemble, and Henry G. Vaughan and Edwin Reynolds of the Shipping Board Recruiting Service.

In the afternoon the delegation went on board the training ship "Governor Dingley" for luncheon and an inspection of seamanship and boat drill by the merchant marine apprentices being trained by the Shipping Board.

Effect of Poor Coal on Plant Efficiency

An interesting analysis of the effect of poor coal on power-plant efficiency was presented at a meeting of the New England Street Railway Club in Boston, Mass., Feb. 28, by Walter C. Slade, superintendent power and lines, Rhode Island Company, Providence. Rhode Island has keenly felt the shortage of bituminous coal. The two power-producing utilities at Providence have been operating of late with inadequate coal reserves and the Rhode Island Company in particular has recently been forced to operate its main power plant at Manchester St. for three or four days entirely with borrowed coal. The company operates two steam plants, one a turbine station at Providence with two 15,000-kw. units and some smaller machines, and one at Rockland, of the engine type. In 1916 these plants burned 73,100 gross tons; in 1917 the consumption rose to 90,500 tons, although the power generated increased less than 5 per cent.

The load on these stations is exclusively railway. The diversity factor which the average central station enjoys does not exist on the Rhode Island system. The turbine station generated 73,492,300 kw.-hr. in 1917 and the Rockland station 1,423,217 kw.-hr. In 1915-16 the company paid $3.32 per ton for coal alongside; discharging cost 8.5c. per ton. The average price is now over $8.35, provided there are no demurrage charges. Owing to Government regulation, the consumer absorbs not only demurrage charges, whether they occur on cars or on the boat at the loading end or at the discharging end, but also other charges such as war taxes, insurance, etc. To date the company has received about $6000 in demurrage bills on the last eleven boats, on which two-thirds was incurred at the loading end. Discharging costs have advanced to 23c. per ton, because the company is now obliged to discharge boats on overtime work to avoid the high demurrage charges. Today coal passers on the water front are getting 50c. per hour straight time, 65c. per hour overtime and 75c. per hour Sundays and holidays.

In August, 1917, the company realized that it was going to have trouble with fires in part of its stored coal, due to the rapid heating properties of some of the coal, which was of poor quality even though of high price. The fire trouble actually occurred earlier than was anticipated. About Sept. 1 shipments became less frequent, and in December the reserve-storage supply was reduced to about 7500 tons. In February the coal left was all consumed and the company was forced to borrow coal through the local fuel administration. For the last year all possible pressure was exerted to have suitable deliveries kept up to prevent the depletion of the supply.

Prior to the time when the coal-mining conditions became abnormal and transportation facilities became demoralized, the company burned New River or Pocahontas coal, with an average analysis of about 14,900 B.t.u. Even the same grade of coal, due evidently to poorer preparation at the mines and at a later time possibly to pooling of coal supplies by the Government, gave noticeably lower average B.t.u. on analysis. The spot cargoes purchased outside, consisting mainly of Pennsylvania coals, but which were expected to be of average quality, were in some instances of extremely poor quality. Of the coal placed in yard storage, 35 per cent. showed a heat value under 14,500 B.t.u., and 46 per cent. under 14,750 B.t.u. In fact, 21 per cent. was under 14,000 B.t.u., some of it containing 15 per cent. ash. Owing to the deterioration of this coal in storage before it was consumed under the boilers, the average B.t.u. value of the coal as fired was not over 14,300 B.t.u. The poor quality of coal was reflected in operating cost, in addition to the higher cost of the coal alongside. Increased boiler-room maintenance also resulted. The net result was to raise the unit cost of power for 1917 by 106 per cent., compared with the year ended June 30, 1916.

The coal factors for both stations have been growing worse since 1916, as shown:

	—Manchester St. Station—		—Rockland Station—	
	Lb. Coal Per Kw.-Hr.	Per Cent. Increase	Lb. Coal Per Kw.-Hr.	Per Cent. Increase
12 months ending June 30, 1916	2.28	....	3.49	....
6 months ending Dec. 31, 1916	2.38	4.4	3.78	8.3
12 months ending Dec. 31, 1917	2.69	18.0	3.99	14 3

The unusually high factor for the turbine plant in 1917 was due to a combination of operating conditions requiring a large number of banked hours on stand-by boilers not used in 1916, together with the necessity of burning a considerable amount of inferior coal, as well as coal damaged by spontaneous combustion. The performance will not be repeated in 1918. In fact, under favorable conditions the plant in Providence was operating for a part of January at 2.13 lb. The decrease in economy at both turbine and engine plants has been of the same relative order.

As regards the increased cost of busbar power, some comparisons may be made with the costs which apply to the year ended June 30, 1916. Comparing the last six months of 1916 and the year 1917 with this period, it is found that the cost per kilowatt-hour at the bus increased for the six months 23.4 per cent. and for the following twelve months, 106 per cent. at the Manchester Street Station. At the small Rockland plant the busbar cost increased for the same periods 31.8 per cent. and 73.5 per cent. These remarkable increases in unit cost are due primarily to the abnormally high price and also to the poor character of the fuel. Some of the coal was of such poor quality that it raised the maintenance of stokers and furnaces to an abnormal point. Steam-plant maintenance in 1917 increased 75 per cent. compared with 1916, and all other maintenance increased only 13 per cent. at the Manchester Street Station. The increase in the cost of fuel as fired was 132 per cent. and raised the fuel charge in 1917 to as much as 83 per cent. of the total maintenance and operating costs. Referring to operating charges in the same year, while fuel costs advanced 132 per cent. over 1916, wages advanced 30 per cent. and all other operating charges 25 per cent. The kilowatt-hours delivered increased only 4.9 per cent. and the pounds of coal per kilowatt-hour 18 per cent.

The majority of the existing railway plants were built at a time when 25 cycles was the only commercial frequency considered suitable for traction purposes. These plants as a rule enjoyed no diversity factor in their load. So much capital is invested in these large railway plants that even though they are able to generate less economically than adjacent central stations, it is difficult to consider anything but a continuance of operation with added improvements in the interest of economy in these railway installations. Between the average large 60-cycle central station and the average large 25-cycle railway plant there can be no interchange of power except through frequency-changing equipment, which is sufficiently uneconomical to make such an exchange feasible only for emergency service. In certain cases it appears feasible to add some 60-cycle

equipment in extending existing 25-cycle plants, where intimate coöperation exists between the two classes of plant owners. The writer believes that many of the smaller railway plants of the engine-driven type should be shut down by central-station service, holding that with increasing cost of coal the balance is all in favor of the central station. It is questionable if the price of coal in future years reaches a minimum that is $1 to $1.50 a ton above prices prevailing before the war.

In ordinary times the fuel item represents from 70 to 75 per cent. of the total cost of generated power. Recently, this reached 83 per cent. on the Rhode Island system. In fact, at least 90 per cent. of the total cost was expended in the boiler room for fuel, water, wages, supplies and materials required for maintenance. The boiler plant has been too much neglected in the past, especially in employing high-priced men to operate it. Now there is a man shortage, and perhaps the best solution is to put under the chief engineer a technically trained man or at least a man who understands the theory of combustion well and who can keep a constant check on the operation of the boiler room. This type of man has been termed "combustion engineer." Even plants of moderate capacity could well afford to maintain such a man on the payroll. Working with the assistance of the necessary measuring devices, such a man could put the true spirit of industrial control into boiler-room practice. To aid the combustion engineer in effecting the desired economies, it is advisable to consider the question of making all equipment as nearly automatic as possible. Man power may be at a premium for some time to come, and at all times undue dependence upon the human element is undesirable.

Toluol from City Gas

In anticipation of the present national emergency, says *Iron Age*, there has been going on without any publicity a development in toluol manufacture which bids fair to be of the utmost importance to the nation in the supply of trinitrotoluol. Early in 1915, the Koppers Co., of Pittsburgh, which at that time was building a large number of byproduct coke plants, and in connection with which it was also building benzol and toluol plants, started in the laboratories of the Mellon Institute, Pittsburgh, an investigation into the recovery of toluol from carburetted water gas, the gas made in all large cities of the country by the gas companies for domestic use.

It has been found that every byproduct coke-oven plant in the country is producing or has arranged to produce toluol to the utmost capacity and that the remaining needed toluol must be secured from city gas. The Pittsburgh By-Product Coke Co., an operating company associated with the Koppers Co., has carried out a plan in conjunction with the gas-light company at Washington to erect the first plant at the West station of that company to effect the removal of toluol from 5,000,000 cu.ft. of carburetted water gas per day. This plant was placed in operation on July 14, 1916, and has yielded since that date 200,000 gallons of toluol. While this plant was the first to use this process, and many improvements increasing the efficiency and economy of operation have been introduced, it proved a commercial and technical success, equaling the results promised by laboratory methods. Many of these "stripping" plants are in operation in various cities, and others are in preparation.

The Belgian Coal and Coke Industry

During the years that immediately preceded the war, Belgium produced, in round figures, 24,000,000 metric tons of coal a year. About 1,350,000 tons of this was coked, yielding a trifle more than 1,000,000 tons of commercial coke, including breeze sold for domestic use. All coke was, of course, byproduct coke, as none other has been made in Belgium since 1892 or 1893.

Belgium was a pioneer in the byproduct industry. The oldest byproduct company now in existence is the Société Anonymé du Charbonnage des Produits, at Flénu, Belgium, which was incorporated in 1856 for the mining of coal and the manufacture of byproducts. That company may have become better known abroad as a coal company than as a byproduct concern, but this was due to the extraordinarily fine natural condition of its coal deposits, which enabled the company to pay big dividends earned in mining and selling coal while meeting the stress of developing the byproduct department of its business. Regardless, however, of the trying period of development, the Produits Co. never ceased for a single day, since 1856, to make byproducts; and the first aniline colors ever put on the market were made at Flénu by this company at a time when its coke and byproduct department was managed by the noted Belgian chemist, Neyrincks.

With the advent of the Coppée vertical-flue coke oven, the Produits Co. became a decided factor in the byproduct industry. That was about 1870, at a time when Germany had only beehive coke ovens and when all coke made in Belgium was produced in retort ovens of the original Coppée design. Not only was Germany later than Belgium in eliminating its beehive ovens, but even to this day there is not in Germany a single coke oven which is not of the vertical-flue kind first invented by Coppée, a Belgian, or the horizontal-flue type developed by Solvay and Semet, the former a Belgian, the latter a Frenchman, both living today. Many persons in this country, even among those engaged in the byproduct industry, believe that the byproduct oven is of German origin and development. To this day the Belgium coke ovens have always kept at least one step ahead of all others.—*Coal Age.*

Science or Art

There are times when we find it difficult to take any interest whatever in education, times when the mere word bores us, calling up dull recollections of tedious debates and the incessant repetition of those platitudes, formulas, pious hopes and bitter criticisms, which for many a long year have been the currency of educational conferences. To men thus weary of the subject, we recommend a little book by H. G. Taylor, lecturer in civil and mechanical engineering at King's College, the University of London. According to their point of view, it will make them angry or rejoice them. If they are university men, if they are mathematicians rather than engineers, they will be roused either to wrath or contempt; if, on the other hand, they are inventors or manufacturers, and, above all, if they are men who owe more to practical training than to college classes, they will applaud the author's argument.

Mr. Taylor is a whole-hearted advocate of a thorough practical training. A Whitworth scholar himself, he believes in the Whitworth method. Engineering, he says quite bluntly, is not a science, it is an art, and it is not to be learned by abstractions, but in the workshop, the factory and the field. A man, he holds, must first be an engineer by nature; he may then be taught to think scientifically, but "to be useful to him, any elementary science must become an idea over which he has complete control." With the exception of the method of training naval cadets, for which he has nothing but the highest praise, Mr. Taylor does not think any one of our universities gives this desirable control. "Without exaggeration," he writes, "for an engineer who has to make his way in life, the worst thing he could possibly do is to become educated." The training that is given in the schools lacks reality, and depends too much upon mathematical abstractions. "To a man with good mathematical knowledge and no engineering experience, all problems resolve themselves into mathematics, and his engineering credulity obtains for him the desired success."

We are disposed to agree with him. The mathematics employed in the ordinary course of mechanical and civil engineering are small indeed, and the advanced teaching is unnecessary, and in many cases even vicious, since it gives a wholly false idea of the truth and encourages a belief in mathematical dogma. Meticulous accuracy in engineering calculations is impossible, because there are always many unknown quantities and qualities. Hence broad calculations which allow a margin for error are always used in practice. For general purposes the engineer will learn more about heat from the experiments and simple arithmetic of Tyn-

dall than from the textbooks of Rankine. The instinct that is acquired by doing things is more useful in this work-a-day world than mathematical abstractions. "The best education for an engineer," says Mr. Taylor, "is found in the natural and instinctive pursuit of manual toil accompanied by study at a technical school." We agree with him. The great engineers of the past learnt by hard experience, and the great engineers of the future will learn by the same methods. The university will never replace the workshop.

There are one or two more words that must be said on this eternal question of mathematics. We went some time ago to visit the dean of a technical college, well known to us in our youth. In our days it was a hotbed of mathematics, and the student who did not revel in the higher flights of "conic sections" had a poor chance, indeed, of achieving distinction. We found a great change. The present dean was bred in the workshop, and he holds that the drawing office rather than the classroom is the proper place to teach the science of figures. With a sly twinkle in his eye, he admitted that on more than one occasion he had found his students busy over their boards, engaged in the actual design of a machine or a structure when they ought to have been attending a lecture on abstract mathematics. His duty obliged him to pack them off straight away, but we could see that his sympathy, as a man and an engineer, went out to them. He knew that these youths had in them the making of real engineers. They were fired by that love of creating, that desire to make things, which is the call of our profession. Where arithmetic or algebra, geometry or the calculus was needed for the construction of something, they used it gladly, as they would any other instrument or tool, but they could not look upon mathematics as an end in themselves. We dare say that this professor is teaching many a man how to handle figures who would never have learned the art from the professors of the subject.

Mr. Taylor is right, we think, when he suggests that mathematics have gained too high an estimation in technical schools. We cannot conceive of an engineer who was unacquainted with the strength of material, the nature of stresses, the means for working metal, stones and timber and the general facts of physics and chemistry. These things and many others must be *known* and handled by the *mind*. But we can quite well conceive a super-perfect Babbage calculating machine that would answer by the turn of handle any mathematical proposition that might be put before it. There are certain things mathematics cannot replace, and it is those things far more than mathematics that should be given the place of honor.

No one, we trust, will run away with the idea that we fail to recognize the value of mathematics; nothing could be further from the fact. Accurate measurement is the basis of science. What we desire to convey is our conviction that good engineers, men of resourcefulness, inventiveness and imagination can be made with far less mathematical knowledge than is now insisted upon. The science of mathematics is best reserved for those who have the aptitude for it. Such men become useful calculating boxes in the hands of others whose natural bent is toward invention and creation. Where you may find a thousand engineers doing useful work in the world with no more than a decent acquaintance with arithmetic, you shall barely find one high mathematician who is also a progressive engineer. —*Random Reflections from The Engineer, London.*

Complaints of Excessive Prices for Soft Coal

Investigation is being made of complaints received by the United States Fuel Administration that operators in some of the bituminous coal fields are charging an excessive price for coal under contracts made before Aug. 21, 1917, embodying prices below those fixed by the President, which contained no sliding scale of labor charges.

Operators against whom charges have been lodged are alleged to be exacting from customers 45c. per ton in addition to the figure set forth in such contracts, and are attempting to defend their course on the ground that they were required to make the increase under the President's order of Oct. 27, 1917, allowing a 45c. per ton increase to cover wage advances for the miners.

Consumers will be protected against such practices of overcharging when their purchases were made under contracts which contained no provision for variations in price to correspond with changes in wage scales. The Fuel Administration previously announced that the President's order in no degree lessened the obligation of operators to make deliveries at prices stipulated in contracts made before Aug. 21, 1917.

Proper steps have been taken to prevent overcharging in such cases. In one case brought to light, one of the large coal companies of the country has agreed to withdraw the 45c. per ton increase which they had imposed in excess of their contract price.

Civilian Workers Wanted for Ordnance Department

Men having a high-school education, some shop training and the natural ability to adapt themselves to new work, may qualify for a Government appointment in which under Government instructors they will receive the necessary training for the following positions: Inspectors and assistant inspectors, field artillery ammunition steel; inspectors, artillery ammunition, cartridge cases, assembling, loading, forging, primers, detonators, shell and shrapnel machining; ballistic inspectors; metallurgical chemists and assistants; inspectors, powder and explosives; inspectors, cannon, forging operations; inspectors, gun carriages and parts; inspectors, gun-fire control instruments; assistant inspectors, motor vehicles and artillery wheels; engineers and assistant engineers, for tests of ordnance materials; inspectors, ammunition packing boxes; machinists, accustomed to work to one thousandth of an inch.

Those who have the required technical training will be placed and advanced as quickly as their ability justifies.

Send in your own application and urge your associates who may be qualified to do so. These positions are under civil-service regulations, but applicants will not be required to report for examination at any place. Applicant will be rated in accordance with education and general experience. No applications will be accepted from persons already in the Government service unless accompanied by the written assent of the head of the concern by which the applicant is employed. Papers will be rated promptly and certification made with least possible delay. Apply or write for further information to C. V. Meserole, Special Representative of the Ordnance Department, U. S. A., Room 800, 79 Wall St., New York City.

Our Greatest Enemy

Comparatively few persons realize how great a toll industrial accidents take of our people every year, states Secretary Redfield. If we are ever so unfortunate as to hear of the loss in a great battle of, say, 10,000 of our soldiers (10,000 killed) the nation would be moved deeply; yet every year twice, perhaps three times, that number are slain in industries of all kinds and almost without its invoking comment. If we were to hear that 1,000,000 of our men suffered wounds in this war, the nation would be troubled; yet industry takes its toll in the form of injuries to persons to an extent nearly three times that number every year. Of this we think but little. There is a real danger, therefore, that in our sympathetic and proper thought for the soldier in the field, we may lose sight of the soldier in the factory, who has his casualty risks as well as his brother in arms. Just as there is a call to service for the soldier and the financier and the nurse and the doctor and the engineer and the mechanic, there is a call to service to see that the precious lives in the country are not wasted and that the bodies of the precious people who make up this country are not crippled.—*Scientific American.*

New Publications

POWDERED COAL AS A FUEL—By C. F. Herington. Published by D. Van Nostrand Co., New York, 1918. Size, 6 x 9 in., 211 pages; illustrated. Price, $3.

The information which the author has collected in this book was largely acquired while he was employed as assistant engineer in the service of the New York Central Railroad Co. Having described the coals suitable for powdering, the preparation and feeding of powdered coal, the author proceeds to discuss the use of fuel in this form in the cement industries, in reverberatory and metallurgical furnaces, under steam boilers and in locomotives. A chapter is devoted to explosions of powdered fuel and a comprehensive bibliography given of the literature of the subject.

COMBINED TABLE OF SIZES IN THE PRINCIPAL WIRE GAGES

A new publication (Circular 67) entitled "Combined Table of Sizes in the Principal Wire Gages," has recently been issued by the Bureau of Standards, Washington, D. C. This table combines in one series the sizes in the American (B. & S.), Steel, Birmingham (Stubs'), British Standard, and Metric Wire Gages, arranged in order of diameters of wires. It gives the diameters of all the gage numbers in these five systems, in mils, inches and millimeters, also the cross-sections in square mils, circular mils, square inches and square millimeters. The table is especially useful to those who wish to determine the nearest equivalent in American or British gage sizes of wires, specified in millimeters or square millimeters, or vice versa. This paper is now ready for distribution and those interested may obtain a copy by addressing a request to the Bureau.

MACHINE SHOP PRACTICE — By William B. Hartman. Published by D. Appleton & Co., New York, 1917. Cloth; 4¼ x 6¾ in.; 235 pages; 132 illustrations; 10 tables. Price, $1.10.

The man who has no knowledge of machinist tools and machine-shop practice will find this volume of value in that it presents the elementary principles of machine-shop work in a simple and logical manner. Measuring tools are first illustrated and explained as to form and use. This subject is followed by a description of hand and machine-cutting tools, and finally the several machines alone and in combination with the tools are treated. Correct methods in the handling of tools and in the operation of machines are emphasized. All higher mathematics are excluded, and all calculations are confined to the use of simple arithmetic. The data tables in the appendix are such as are found in the general run of handbooks, but they will be useful to the student. The contents cover the following subjects: Chipping; filing and scraping; drills and drilling machines; lathes; straight turning; taper turning; thread cutting; lathe work; planer and shaper; boring mills; milling-machine work; and a chapter dealing with the automobile. Each chapter is concluded by a list of questions. The illustrations are confined to mechanical drawings which will assist the reader in learning to read them and as to their use.

THEORY AND OPERATION OF DIRECT-CURRENT MACHINERY. By Cyril M. Jansky. Published by McGraw-Hill Book Co., New York, 1917. Cloth; 6 x 9 in.; 285 pages; 214 illustrations. Price $2.50.

This book has been prepared as a text to meet the needs of students of limited mathematical training. Elementary mathematics has been made use of quite extensively throughout the work, nevertheless the subject has been presented so that an understanding of the principles involved may be obtained even though the reader may be unable to follow the mathematical reasoning.

The book is divided into sixteen chapters embracing fundamental magnetic principles, electromagnetism, electromagnetic induction, units of measurement, transformation of energy, the continuous-current generator and motor, the magnetic circuit of the direct-current dynamo, armatures, uses of electrical energy, types of dynamos, commutation, operating characteristics of generators, operation and care of generators, operating characteristics of motors, operation of three-wire systems, selection and installation of dynamos.

Although this book was written primarily for use in the classroom, it contains much that the practical man can make good use of, especially the last eight chapters, which deal largely with the construction and operation of direct-current machinery. In the first four chapters the author has given considerable space to a discussion on the theoretical magnetic and electrical units, making it clear just what these units are and how they are arrived at.

Obituary

Findlay Clem was killed on Feb. 25 while inspecting a boiler at Owens Station, near Marion, Ohio. He was employed by the J. T. Adams Construction Co.

Personals

M. H. Collins has been appointed sales manager of the new Louisville (Ky.) branch of the Rensselaer Valve Co.

G. W. Bichlmeir, formerly connected with the supply departments of the Missouri Pacific and Kansas City Southern Railway Companies, and also secretary-treasurer of the W. L. Sullivan Machinery Co., is now connected with the machinery department of the Walter A. Zelnicker Supply Co., St. Louis, Mo.

H. A. Brassert, who has been connected with the United States Steel Corporation since its organization, has resigned as assistant general superintendent of the Illinois Steel Co. at South Chicago, in order to devote himself to his personal interests. He will act as vice president of the Miami Metals Co. and subsidiaries, consulting engineer for Freyn & Co, and in a consulting and advisory capacity with the firm of Brassert, Hardy & Tripp. His offices are in the Peoples Gas Building, Chicago.

Loyall A. Osborne, of New York, vice president of the Westinghouse Electric and Manufacturing Co. and chairman of the Executive Committee of the National Industrial Conference Board, has been appointed by the Secretary of Labor a member of a committee on industrial peace during the war. This committee, which consists of five representatives of employers, five labor leaders and two public men, will provide a definite labor program in order that there may be industrial peace during the war, thus preventing interruption of industrial production vital to the war.

Engineering Affairs

The Sinton Hotel, Cincinnati, Ohio, has been selected as the headquarters for the N. A. S. E. Convention, Sept. 16-21, 1918.

The New York State Educational Committee of the N. A. S. E. and Combined Associations of Greater New York will hold a meeting on the evening of Mar. 26, at 220 E. 15th St., New York City. Walter N. Polakov will give a lecture on "Power-Plant Management," and W. R. Marshall will give a talk on "The Operation of Steam Turbines and Their Auxiliaries." Through the courtesy of Mr. Shillcocks a visit will be made to the power plant of the Loose-Wiles Biscuit Co., Thompson Ave., Astoria, L. I. on the evening of Mar. 22.

Miscellaneous News

A Boiler Exploded at Sharp's farm, Plum township, Penn., on Mar. 8, killing one man and injuring three others. The men were drilling an oil well when the boiler exploded.

A Freight Engine Blew Up on the Wabash R. R. near Cerro Gordo, Ill., on Mar. 3, injuring four persons, wrecking 19 loaded cars, and breaking windows two miles away. The engineer was blown about 20 ft. away.

A Locomotive Boiler Exploded on the Santa Fe R. R. two miles west of Williard, N. Mex., on Mar. 3, instantly killing the engineer and fireman and slightly injuring another man who was riding a horse near the scene of the explosion.

Business Was Temporarily Disrupted in St. Louis, Mo., at noon on Mar. 1, when power furnished the Union Electric Co. from the Keokuk Dam failed. The trouble was caused by the grounding of a high tension transmission line.

An Explosion in the Engine Room of the Farley & Loetscher Manufacturing Co.'s plant, at Dubuque, Iowa, on Feb. 21 seriously injured three persons and two men were still missing when the report of the accident was received. The explosion followed a fire that spread into one of the big sawdust conveyors.

The Magnesia Association of America is issuing a portfolio of all the educational publicity given its product during 1917 in the various technical and trade papers, under the title, "Let 85% Magnesia Defend Your Steam." Anybody interested may secure a copy by writing to the secretary of the Association at 702 Bulletin Building, Philadelphia, Penn.

The Bureau of Standards at Washington has purchased eight acres of land west of Connecticut Ave. and has let contracts for a new engineering laboratory, 175x350 ft. and four stories in height. The new building and its equipment will cost in the neighborhood of $1,000,000, and will increase the capacity of the Bureau by 50 per cent. The Pittsburgh laboratory of the Bureau, including the work on glass and ceramics, will be transferred to Washington. It is expected that the new building will be occupied during the coming summer.

Business Items

The Wheeler Condenser and Engineering Co. announces the removal of its Philadelphia office to the Land Title Building, with L. McKendrick as district manager.

The Ketzer Machinery Co. has consolidated with W. H. Robinson & Co., with offices in the Real Estate Trust Building, Philadelphia. Paul R. Ketzer is manager in charge.

The Permutit Co., manufacturers of water-softening and water-rectification apparatus, for several years located at 30 East 42nd St., New York, announces its removal to 440 Fourth Ave.

The Worthington Pump and Machinery Corp. announces the following appointments in its organization: William Goodman, assistant to vice president; William Schwanhausser, chief engineer; Edward T. Fishwick, general sales manager; Charles E. Wilson, assistant general sales manager; James E. Sague, vice president, in charge of engineering and manufacturing; Leon P. Feustman, vice president, in charge of general commercial affairs; Frank H. Jones, vice president, in charge of sales; all at New York City offices, 115 Broadway. Neil C. Lamont, works manager, Laidlaw Works, at Elmwood Place, Cincinnati, Ohio.

Trade Catalogs

Ammonia Fittings and Accessories. De La Vergne Machine Co., Foot of E. 138th St., New York. Catalog. Pp. 92; 6 x 9 in.; illustrated. This company has also issued a bulletin giving ammonia-compressor capacity and list of installations.

Safety Enclosed Fuses, Electrical Protective Equipment and Materials. Electric Fuseguard Co., Newark, N. J. Catalog No. 1. Pp. 54; 6 x 9 in.; illustrated. Describes this company's line of safety electrical-protective equipment and allied materials; list prices are also given.

Electrical Equipment in the Woodworking Industry is the title of a new circular just issued by the Westinghouse Electric and Manufacturing Co., East Pittsburgh, Penn. The publication is illustrated by views of motor-driven wood-working machinery. In the first section the general subject of motor drive is discussed. The next section is devoted to features of Westinghouse motors which make them suitable for this work. The rest of the book gives horsepower requirements and other data for many different sorts of wood-working machinery which will be of much value to those having to do with this class of industrial activity.

THE COAL MARKET

Boston—Current quotations per gross ton delivered alongside Boston points as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	Mar. 14, 1918	One Year Ago	Mar. 14, 1918	One Year Ago
Buckwheat	$4.60	$2.05—3.20	$7.10—7.35	$3.25—3.50
Rice	4.10	2.50—2.65	6.65—6.90	2.70—2.95
Boiler	3.90	.....	.....	.....
Barley	3.60	2.20—2.35	6.15—6.40	2.35—2.60

BITUMINOUS

Bituminous not on market.

	F.o.b. Mines*		Alongside Boston†	
	Mar. 14, 1918	One Year Ago	Mar. 14 1918	One Year Ago
Clearfields	.....	$3.00	.....	$4.25—5.00
Cambrias and Somersets	.....	3.10—3.85	.....	4.60—5.40

Pocahontas and New River, f.o.b. Hampton Roads, is $4, as compared with $2.85—2.90 a year ago.

*All-rail rate to Boston is $2.60. †Water coal.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	Mar. 14, 1918	One Year Ago	Mar. 14, 1918	One Year Ago
Pea	$5.05	$4.00	$5.80	$7.25—7.50
Buckwheat	4.30—5.00	2.75	5.50—5.80	7.00—7.25
Barley	3.25—3.50	1.95	4.00—4.25	4.00—4.25
Rice	3.75—3.95	2.20	4.50—4.80	5.00—5.50
Boiler	3.50—3.75	2.20	.....	3.50—4.00

Quotations at the upper ports are about 5c. higher.

BITUMINOUS

	F.o.b. N. Y. Harbor	Mine
Pennsylvania	$3.65	$2.00
Maryland	3.65	2.00
West Virginia (short rate)	3.65	2.00

Based on Government price of $2 per ton at mine.

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The freight rate to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Mar. 14, 1918	One Year Ago	Mar. 14, 1918	One Year Ago
Pea	$3.75	$2.80	$4.65	$3.70
Barley	2.15	1.85	2.40	2.05
Buckwheat	3.15	2.50	3.75	3.40
Rice	2.65	2.10	3.65	3.00
Boiler	2.45	1.95	3.55	3.15

Chicago—Steam coal prices f.o.b. mines:

Illinois Coals	Southern Illinois	Northern Illinois
Prepared sizes	$2.65—2.80	$3.35—3.50
Mine-run	2.40—2.55	3.10—3.25
Screenings	2.15—2.30	2.85—3.00

Smokeless Coals	So. Illinois, Pocahontas, Pennsylvania and West Virginia	Hocking, East Kentucky and West Virginia Splint
Prepared sizes	$2.60—2.85	$2.85—3.35
Mine-run	2.40—2.60	2.60—3.00
Screenings	2.10—2.55	2.35—2.75

St. Louis—Prices pet net ton f.o.b. mines a year ago as compared with today are as follows:

	Williamson and Franklin Counties		Mt. Olive and Staunton		Standard	
	Mar. 14, 1918	One Year Ago	Mar. 14, 1918	One Year Ago	Mar. 14, 1918	One Year Ago
6-in. lump	$2.65-2.80	$3.25-3.50	$2.65-2.80	$3.25-3.50	$2.65-2.80	$2.50-2.75
2-in. lump	2.65-2.80	.....	2.65-2.80	.....	2.65-2.80	.....
Steam egg	2.65-2.80	.....	2.65-2.80	.....	2.65-2.80	.....
Mine-run	2.40-2.55	2.75-3.00	2.40-2.55	3.00	2.40-2.55	2.25-2.50
No. 1 nut	2.65-2.80	3.25-3.50	2.65-2.80	3.25-3.50	2.65-2.80	2.35-2.75
2-in. screen	2.15-2.30	2.50-2.75	2.15-2.30	2.75-3.00	2.15-2.30	2.25-2.50
No. 5 washed	2.15-2.30	3.00	2.15-2.30	2.75-3.00	2.15-2.30	2.5(

Williamson-Franklin rate St. Louis, 87½c.; other rates, 72½c.

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Lump and Nut	Slack and Screenings
Big Seam	$1.90	$2.15	$1.65
Pratt, Jagger, Corona	2.15	2.40	1.90
Black Creek, Cahaba	2.40	2.65	2.15

Government figures.

[1]Individual prices are the company circulars at which coal is sold to regular customers irrespective of market conditions. Circular prices are generally the same at the same periods of the year and are fixed according to a regular schedule.

PROPOSED CONSTRUCTION

Fla., Christina—The Phosphate Mining Co. plans to rebuild its electric power plant which was recently destroyed by fire. P. H. Fuller, Nichols, Gen. Mgr.

Idaho, Dubois—The Dubois Light and Power Co., recently incorporated with $25,000 capital stock, plans to build an electric-lighting plant on Beaver Creek near here.

Ind., Richmond—J. P. Dillon, Supt. of the electric-lighting plant, has requested the City Council to appropriate $200,000 for an extension to the plant.

Kan., Bunkerhill—City is considering the erection of an electric-lighting plant.

Ky., Louisville—The Progress Laundry Co., 716-720 Broadway, plans to purchase electrical equipment including a 100 hp. engine.

Md., Baltimore—The Bartlett Hayward Co., Scott and McHenry St., has awarded the contract for the erection of a 28 x 49 ft. transformer house, to Morrow Bros., Fidelity Bldg.

Mass., Medfield—The Commission on Mental Diseases will soon receive bids for replacing main steam line to various buildings with large line and extensions. The work involves 3850 sq.ft. radiation, Jenkins valves, 240 ft. 1½ in. pipe mains to various building and large 3 in. steel pipe.

Minn., Lanesboro—City plans an election soon to vote on $15,000 bonds for the erection of an electric-lighting plant. H. T. Asbre, City Clerk.

Miss., Clinton—City plans to install additional equipment in its power plant. Estimated cost, $8000. J. W. Provine, Mgr.

Mo., Concordia—The Trustees of St. Pauls College have plans under consideration for the erection of a new power plant at the institution. C. F. May, Merchants Lacleded Bldg., St. Louis, Arch.

Mo., Kansas City—The Kansas City Light and Power Co. will build a 4-story, 185 x 244 ft. power plant on Front St. and Park Ave. A. N. Richardson, Gen. Supt.

Mo., Lewistown—H. H. Bronson is in the market for direct current generators.

Mo., Marshfield—The Marshfield Electric Co. plans to improve and alter its plant; a new generating unit will be installed.

Mo., St. Louis—E. W. Leverett, Supt. of the lighting system, is in the market for a generating unit and power plant equipment to replace 150 hp. equipment now in use.

N. Y., Brooklyn—The Arabol Manufacturing Co., 100 William St., New York City, is having plans prepared by H. Harlach, Engr., 451 East 144th St., New York City, for the erection of an addition to its boiler house on Sanford St., here.

N. Y., Buffalo—The Delaney Forge and Iron Co., 300 Perry St., is in the market for power plant equipment of about 500 hp.

N. Y., Buffalo—The Pullman Co., 79 East Adams St., Chicago, plans to purchase power plant equipment.

N. Y., Elmira—Hilliard Clutch and Machine Co., 4th St., plans to install a steam heating extension to its present plant. Electric motors will be purchased.

N. Y., Elmira—The Willys-Morrow Co., Toledo, Ohio, is in the market for power plant equipment.

N. C., Badin—The Tallassee Power Co. plans to build 200 additional buildings to its plant soon. G. R. Gibbons, Pittsburgh, Secy.

Ohio, Atwater—The Atwater Light and Power Co., incorporated with $10,000 capital stock, plans to build and operate an electric-lighting plant. E. P. and P. W. Whittlesey and others, interested.

Ohio, Cincinnati—J. A. Fay & Egan Co., John and Front Sts., will install power plant equipment in its proposed wood-working factory.

Ohio, Cleveland—City is in the market for 1333 electric meters ranging from 5 ampere, 110 volt single phase meter to 220 ampere, 110 volt potential transformers. E. Shattuck, City Purchasing Agent. R. Hoffman, City Engr.

Okla., Kingston—City plans to rebuild its electric-lighting plant which was recently wrecked by an explosion.

Penn., Philadelphia—The Cocoa Butter Manufacturing Co. has had plans prepared by A. F. Sauer & Co., Engr., 908 Chestnut St., for a new 1-story, 50 x 60 ft. brick power house to be erected at 2626 Martha St. Noted Mar. 12.

Wash., Bellingham—The Puget Sound Traction Co., Stuart Bldg., Seattle, plans to build a transmission line from here to the Cokedale Mine to furnish horsepower to the plant there. J. Harisberger, Gen. Supt.

Wash., Seattle—The City will build a power station for the lighting department at 14th Ave., N. W., and 49th St. The work will be done by day labor. Noted Jan. 22.

W. Va., Fireco—The Battleship Coal Co., Princeton, plans to build a central power plant at its mines, here. H. E. Hines, Pres.

Wis., Neenah—The City Council plans to purchase electric equipment for its stone quarry.

Ont., Hamilton—The Imperial Oil Co., 56 Church St., Toronto, has had plans prepared by J. L. Havill, Engr., for the erection of a pump house. Estimated cost, $5000.

Ont., Port Dover—The Town Council plans to install a hydro system. J. Slian, Town Clk.

Que., Montreal—The Southern Canada Power Co., Coristine Bldg., is in the market for a 150 kw. and a 300 kw. motor generator set, second hand, the generator end 250 volts direct current, motor end 3 phase, 60 cycle, 220 volts synchronous motor, or separate machines of identical capacities and characteristics. L. C. Haskell, Purchasing Agent.

Que., Verdun—The Town Council will soon receive bids for repairing and reinforcing its electric-lighting and water works plants. Estimated cost, $50,000. G. A. Ward, Town Clerk.